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U.S. COLLABORATIVE-ENGAGEMENT WITH CHINA: USING STRATEGIC TECHNOLOGICAL COLLABORATIVE LEADERSHIP (STCL)

by

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13. ABSTRACT (maximum 200 words)

China and the United States have taken different paths to arrive at their respective stage of technological development. The United States obtained leadership in technological innovation through its competitive bid to remain technologically superior to the Soviet Union during the Cold War. China developed late, taking a leapfrog approach to play catch-up to the West. This is now changing as Cold War priorities end and globalization provides incentives for off-shoring of U.S. technology companies to China. The shift to rely more on Commercial-off-the-Shelf (COTS) for military technology means keeping the United States a leader in innovative, civilian technologies is a security issue complicating this economic interdependence. Since technological interdependence with China is a given, how can the United States compete with China economically, politically, and militarily in East Asia? Export controls, that kept technology out of the hands of the Soviet Union during the Cold War, do not work in a global political economy where commercial competitiveness is so vital and technology rapidly innovates and has global availability. A new comprehensive approach is needed to solve the inadequate dual-use technology export control structure. This new approach is required to meet current and future U.S. security and economic demands.

The United States should use Strategic Technological Collaborative Leadership (STCL) to lead the region in finding new technological solutions for the region's environmental and energy demands. STCL would then lend itself to a Collaborative-Engagement policy that would have political, security, economic, and social benefits for the United States and the entire East Asian region. The collaborative structure set up in the United States to support this policy will also provide a comprehensive means to ensure an efficient and effective technology control process. This process would ensure critical dual-use technology innovations stay within the United States and thus preserve the U.S. innovative technology base while minimally affecting commercial trade with China. These policy attributes will be especially important as nanotechnology, which is inherently interdisciplinary and collaborative, brings innovations with the promise of further enhancing this collaborative effort in a positive direction. There is an opportunity to find the maximum utility for this new technology through collaborative-engagement. If this opportunity is not taken, China and the United States, and the world for that matter, could enter a very dangerous period of an arms race based on this potentially deadly new technology.

14. SUBJECT TERMS Globalization, Strategic Technological Collaborative Leadership, Social Construction of Technology, Foreign Direct Investment, Multinational Corporations, Social Constructivist, Global Political Economy, Economic Interdependence, Collaborative Sphere of Influence

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U.S. COLLABORATIVE-ENGAGEMENT WITH CHINA: USING STRATEGIC TECHNOLOGICAL COLLABORATIVE LEADERSHIP (STCL)

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ABSTRACT

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I. TECHNOLOGY, GLOBALIZATION, AND NATIONAL SECURITY

Since the end of World War II, the United States has been a superpower of technological innovation, military dominance, and commercial trade. Much of this production power and technological innovation was a direct result of a nationally led military buildup necessitated by World War II and continued by the Cold War.[1] The U.S. government funded several high technology research and development initiatives, such as the Manhattan Project, that would drive a worldwide technological revolution. Then, through incentives and lucrative but exclusive contracts, the U.S. government insured that U.S. production centers would manufacture a majority of the technologies needed by the military.[2] The perceived threat associated with the Cold War created an efficient relationship between the U.S. military and these production centers or Military Industrial Complex (MIC). MIC production was prioritized by the requirements of the military for the best equipment and cost for mission accomplishment.[3] However, benign innovations stemming from this production crossed over into the commercial sector creating a synergistic relationship between the two that enhanced the U.S. commercial economic position.[4]

Conversely, when the Cold War ended, the threat that had provided the impetus for exclusive military production ended along with the competitive efficiency between the military and the MIC. The healthy relationship that kept military requirements a priority for the civilian sector now shifted to political priorities of achieving a peace dividend.[5] As military spending flattened, the incentives that had driven exclusive MIC R&D and production reduced, leaving an excess military industrial capacity. To mitigate

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1 Eugene Gholz and Harvey M. Sapolsky, "Restructuring the U.S. Defense Industry," *International Security*, 24:3 (Winter 1999-2000): 5-7.

2 Ibid., 7-9.

3 Ibid., 16.

4 Glenn R. Fong, Breaking New Ground or Breaking the Rules: Strategic Reorientation in U.S. Industrial Policy*, International Security*, 25:2 (2000).

5 Gholz and Sapolsky, 17-22.

this inefficiency, a new policy in the early 1990s resulted in acquisition and Military Specification (MILSPEC) reform. The belief was to allow the free market to revitalize and bring efficiency to the MIC.[6] The military shifted from a policy that provides incentives for custom produced military items to a policy that encourages buying items "commercial off-the-shelf" (COTS). As military-driven production centers consolidated, military COTS expanded to include computers, communication devices and component parts for the production of larger scale military hardware.[7]

While this change in the acquisition of military goods was occurring, a revolution in the commercial marketplace was changing the face of world trade. Up to this point, the United States parlayed its technological advantage with a strict export control regime; this ensured technological innovation would not fall into enemy hands, particularly those of the Soviet Union.[8] However, as the new COTS directive loosened government control over military goods, the Internet and satellite communications, primarily developed for military use, found their way to the free market. These technologies, combined with the power of the computer, allowed for the instant transfer of information across the globe, making barriers such as distance irrelevant, eventually allowing regional or national production centers to become global. Taking advantage of this, U.S. companies, looking for ways to reduce domestic production costs, began moving production sites to foreign countries, such as China, in order to exploit its cheap production and labor costs. In order to broaden their market share and compete with foreign entities, U.S. companies demanded that foreign export controls be relaxed.[9] However, as sensitive and unauthorized technology information was inevitably passed to foreign workers in China, it was argued that export controls needed to be reinstated to maintain the secrecy and efficacy of U.S. military type dual-use technologies.[10] Soon, globalization of trade and

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[6] Gholz and Sapolsky, 30.

[7] Ibid., 25-30.

[8] Arvind Parkhe, "U.S. National Security Export Controls: Implications for Global Competitiveness of U.S. High-Tech Firms," *Strategic Management Journal*, 13:1 (January 1992): 47-66.

[9] Cox Report, U.S. National Security and Military/Commercial Concerns With the People's Republic of China, Select Committee United States House of Representatives, 1999, Chapter 1.

[10] Ibid.

diffusion of ideas and information meant that the U.S. and China's economies formed a symbiotic interdependent economic relationship further complicating security concerns and export control effectiveness.

The interdependence of politics and economics in global trade forms a structure referenced in this thesis as the Global Political Economy (GPE).[11] With global politics and economics bound in an interdependent structure, dealing with the GPE realistically is an essential factor for any successful U.S. foreign policy toward China.[12] China has positioned itself to take advantage of globalization with its relative advantages in labor, and production costs, as well as a national strategy to exploit the global marketplace and modernize its military.[13] Consequently, the United States must formulate a competitive national agenda recognizing the constraints imposed by the GPE in order to maintain a constructive political and economic policy with China. This is especially true now with China rising to become one of the strongest global competitors to the United States economically, politically, and militarily.

Since innovative technology advances gained by China through the process of globalization is inevitable, this thesis will recommend a policy that would best meet the United States' political, economic, and security interests in East Asia. It will also explore how the United States can maintain a global technological leadership position while mitigating China's rise politically, economically, and militarily. This thesis argues that in order to accomplish this, a nationally led collaborative-engagement foreign and trade policy with China is required. This policy would center on a new technology initiative using Strategic Technological Collaborative Leadership (STCL) that uses U.S. innovative knowledge for the greatest utility, rather than relying solely on inferior protectionist or strict laissez-faire policy measures. The collaborative technology structure set up in the United States will ensure technological innovations, processes, and knowledge that warrant controls to China are identified early, strategically communicated, and

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[11] Geoffrey R. D. Underhill, "State, Market, and Global Political Economy: Genealogy of an (Inter-?) Discipline," *International Affairs*, 76:4 (2000): 805-807.

[12] Ibid., 817, 818.

[13] Evan A. Feigenbaum, "Who's behind China's High-Technology 'Revolution'?: How Bomb Makers Remade Beijing's Priorities, Policies, and Institutions," *International Security*, 24:1 (1999).

implemented effectively. This collaborative structure will be implemented between the U.S. MIC and the civilian sector as well as between the United States, China, and the East Asian region. The need for this collaborative technology policy will be examined in the failure of current export control policies beginning in the mid 1990s.

As background to the importance that technological innovation plays in the process of globalization, the importance of leading in the innovative race, and security implications, it is useful to understand globalization's basic dynamics. Globalization is an evolving process through which humans, existing as separate social, political, and economic groups, adapt and take advantage of widespread-shared information and a shrinking globe brought about by technological innovation. Technology allows information to flow across continents in near real time. This information can be of various forms, from social, business, political to technology or religion. In this manner, the means of informational flow is dependent upon Information Technology (IT) to provide its end. IT fosters more efficient and effective ways to transmit, store, process data or usable information.[14] One of the offshoots of this process is the spread, or diffusion, of technological innovation brought about by economic and social integration, cooperation, and collaboration.[15] As multi-national enterprises with their associated capital flows and labor pools become global, technology diffusion is required to maintain optimal global transactional efficiency and market profitability.[16] Technology diffusion is the spread of technology in the form of hardware, software and associated knowledge. "From this process, economic value becomes less tangible, more fluid, accessible, and portable across political boundaries."[17] The erosion of political boundaries results in the diffusion of the nation-state authority to, "multinational enterprises, worldwide

[14] John Arquilla, "Patterns of Commercial Diffusion." In *The Diffusion of Military Technology and Ideas*, ed. Emily O. Goldman and Leslie C. Eliason (Stanford, CA, Stanford University Press, 2003), 348.

[15] Emily O. Goldman and Andrew L. Ross, "The Diffusion of Military Technology and Ideas-Theory and Practice," In *The Diffusion of Military Technology and Ideas*, ed. Emily O. Goldman and Leslie C. Eliason (Stanford, CA, Stanford University Press, 2003), 377-380.

[16] David C. Gompert, "Right Makes Might: Freedom and Power in the Information Age," *McNair Paper 59*, (1998): 2.

[17] Ibid.

communications, and sundry nongovernmental actors."[18] A core benefit of globalization is a global market that takes advantage of globally traded countries' relative advantages and efficient allocation of resources.[19] These advantages allow a relatively higher quality of life by keeping goods and services relatively inexpensive; this of course, only applies for those who can take advantage of what this market has to offer. Therefore, with technological innovation the motive force behind globalization, it is logical that the country that leads with key innovation gains the upper hand in leading and controlling the global market. "The diffusion of technology does not sap but instead strengthens the enterprises and nations that invent and export it."[20]

However, a dichotomy arises between the process of globalization and national security; as globalization brings the world closer with diffusion of technological innovation, it likewise diminishes the authority of the individual state. Globalization and associated global enterprises provide a form of global governance for the international system of states centered on global economic growth.[21] With increased social and political interaction as a natural progression of globalization and its associated complex interdependencies, power politics and associated security concerns seem out of place. The fact is that state governments are still in competition and worry about relative military capabilities with respect to national security. This duality brings about the need to satisfy both economic and military requirements with technology. It appears that the process of globalization and national security is a zero sum proposition. "These factors seem locked in a tight zero-sum embrace, as more attention to security considerations may have to supersede the pursuit of profits."[22]

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[18] Gompert, 2.

[19] Stephen J. Flannagan, Ellen L. Frost, and Richard L. Kugler, *Challenges of the Global Century: Report of the Project on Globalization and National Security* (National Delaware University, Washington, D.C., 2001), 9.

[20] Gompert, 2.

[21] Ibid.

[22] Arquilla, 368.

The security implications inexorably linked to dual-use technology trade, those innovations traded that have both military and commercial applications, is a major focus of this thesis. “The ‘dual-use’ phenomenon is endemic to the technological realm; thus industry advances may often benefit both commerce and military capabilities.”[23] This dual-use phenomenon is the microcosm of the larger argument about globalization and related complex interdependence and power politics and related security concerns. Globalization, it appears for China, keeps the dragon well fed and ready to do battle. “If Globalization diffuses then power politics concentrates, and even with the diffusion of economy and nation-states, it is still superior relative material capabilities that determine international conditions which can control the global market, and also decide war and peace.”[24] To mitigate the risks associated with the apparent security trade off, in particular the transfer of militarily sensitive dual-use technology, states try to impose diffusion controls against states deemed a national security risk.[25] These are commonly called export controls and come into conflict with economic free trade, open competition and the spirit of laissez-faire. It follows that a more conservative security policy approach on trade with China will improve national security but possibly have a negative affect on economics. Conversely, the opposite holds true with a more liberal approach embracing globalization and free trade but jeopardizing security. However, such dichotomous policies are antiquated in light of the globalization revolution and needs replacing with a collaborative technology policy that embraces economic interdependence, new collaborative technology controls, while at the same time protecting vital U.S. innovative strength.

This thesis will analyze the different dynamics between China and the United States regarding military technological innovations and diffusion. The first section analyzes the historical paths China and the United States have taken concerning technological innovation and diffusion for both military and commercial requirements.

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[23] Arquilla, 351.

[24] Gompert, 2.

[25] Emily O. Goldman, “Receptivity to Revolution.” In The *Diffusion of Military Technology and Ideas*, ed. Emily O. Goldman and Leslie C. Eliason (Stanford, CA, Stanford University Press, 2003), 301.

The second section provides two case studies that will better understand the effectiveness of the current U.S. dual-use technology transfer controls with China and the associated commercial and military implications. The final section provides a policy analysis and policy recommendations that recognize that the United States must effectively compete to remain the innovative leader and maintain control over existing and new technologies through its leadership and influence in the collaborative process thereby ensuring both economic and national security.

A. CHINA AND THE UNITED STATES: HISTORICAL CONTRASTS OF TECHNOLOGICAL DEVELOPMENT

The Cold War ushered in a continuous military technology race between the United States and the Soviet Union. Toward the end of the Cold War, China emerged from its early backward technological policies and capitalized on a more realistic policy approach that took advantage of capitalism and the open market.[26] This new approach would seek to take advantage of existing technologies offered from its traditional ideological ally, Russia, and with new global economic trading partners, such as the United States, Japan, and European Union.[27] Additionally, China's economic growth rate is expanding its domestic market, and capitalizing on this market will become an important economic incentive for U.S. commercial technology innovation there.[28]

1. U.S. Technology Development

Following the end of the Second World War, the United States has been the leader in technological innovation. Much of the global innovative technologies today have roots in the United States and this era. From computers, software, and the Internet, the United States has pioneered much of the information revolution. This drive to innovate came mainly from the competitive nature fostered during the Second World War

[26] Wayne M. Morrison, *China's Economic Condition*, (CRS IB98014, 2006): 2.

[27] Adam Segal, "Practical Engagement: Drawing a Fine Line for U.S. – China Trade," *The Washington Quarterly* 27:3 (2004): 161.

[28] Morrison, 1.

and the subsequent Cold War with the Soviet Union.[29] To win this race, the United States government explicitly sponsored military technology initiatives designed to stay ahead of the Soviets, and by extension, enhancing its global security. "High levels of perceived security threat increased U.S. policymaker's respect for military advice on weapons procurement and research and development (R&D) decisions."[30] The security priority created by the Cold War ensured relatively high federal R&D funding for existing and frontier technologies. Since the early 1960s, many key U.S. government technology initiatives have been introduced under a central agency named the Defense Advanced Projects Agency (DARPA) or ARPA as previously named.[31] DARPA funds basic and exploratory technology R&D to industries and universities to meet this goal. There are currently over 80 technology research areas managed by DARPA.

This agency has helped solidify the United States' standing as the world's leader in technological innovation. The main historical initiatives of DARPA include:

- Sketchpad (1961-63), ARPA Network (ARPANET), 1967-75
- Very High Speed Integrated Circuits (VHSIC), 1980-present
- Strategic Computing Initiative (SCI), 1983-present
- SEMATECH (1987-present), Advanced Lithography (AL), 1988-present
- High Performance Computing and Communications (HPCC), 1992-present
- National Flat Panel Displays Initiative (NFPDI), 1994-present
- Advanced Technology Program (ATP), 1994-present (managed by the Commerce Department)
- National Nanotechnology Initiative (NNI), 2000-present (managed by the Commerce Department)

Of particular interest in the progression of these initiatives is how DARPA has reoriented its objectives starting from a strictly military mission to a more commercial

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[29] Joseph S. Nye, Jr. and William A. Own, "America's Information Edge," *Foreign Affairs* 75:2 (1996): 20.

[30] Gholz and Sapolsky, 5.

[31] Fong, 153.

oriented development.[32] This shift in focus correlates to an increase in global commercial competitiveness, the end of the Cold War and its implications, and increased U.S. military technology requirement reliance on Commercial-off-the-Shelf-Technology (COTS). This progression shows that there have been past technology policies, or strategies, the United States used that worked well during the Cold War. However, a new technology initiative needs implementing that focuses to address China's rising competitiveness and U.S. economic and security needs.

Two important DARPA initiatives throughout the 1960s and into early 1970 were Sketchpad and ARPANET. Military mission requirements were the main impetus behind these initiatives. During most of the Cold War, the United States faced limited global technological competition. Without the worry of commercial competitiveness, any commercial diffusion from these technology initiatives was unintentional or unplanned. In the early Cold War era, the U.S. Air Force needed a more modern way to interconnect its early warning radar system used to track Soviet bombers. The Semi-automatic Ground Environment (SAGE) project, funded by the U.S. Air Force, with collaboration from MIT's Lincoln Labs, developed computer technology to interconnect radar systems together, and provide a interactive display system. It was on this computer technology that a new form of computer interactive graphics called Sketchpad and the ability to develop a "distributed redundant communications network that could withstand a nuclear first strike," (ARPANET) were conceived.[33] These two initiatives would be managed under DARPA.[34]

These two programs would spawn unintended commercial spin-offs that would help propel the United States as the leader of the information age. Sketchpad's commercial spin-offs include innovative computer graphics developed and used by

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[32] Fong, 160-165.

[33] Don Bissell, Graphical User Interface Gallery Guidebook, "The father of computer graphics" http://www.guidebookgallery.org/articles/thefatherofcomputergraphics (accessed December 2007); Lexikon, "History of Computing" http://www.computermuseum.li/Testpage/IBM-SAGE-computer.htm (accessed December 2007).

[34] Fong, 162, 163.

innovative leaders such as Silicon Graphics, Lucas Films, Pixar, and Adobe Systems.[35] ARPANET, with its distributed nodes located at universities and commercial contractors throughout the United States, fostered one of the most important commercial spin-offs, the Internet.[36] Another unintentional spin-off stemming from the ARPANET was electronic mail or e-mail has become a mainstay in commercial, as well as military personal communications.[37] These commercial spin-offs would be the genesis and foundational technology of globalization we know today.

The commercial viability of ARPANET and Sketchpad fostered the first transitional development shift in the 1980s that hoped to realize the economic benefits of commercial spin-offs. However, even though VHSIC and SCI development had an intentional spin-off plan, this early dual-use development model still heavily favored military over commercial development.[38] The VHSIC objectives were to develop advanced semi-conductor technologies required for military superiority. Circuit miniaturization and processing speed was the primary R&D focus.[39] This led to many commercial spin-offs, "over 75 percent of VHSIC program will provide either direct or indirect fallout to the consumer marketplace."[40] Some notable commercial spin-offs include, Digital Signal Processing (DSP), used in digital motor controls, collision avoidance systems, and wireless computing and communication devices.[41]

Another strategically implemented technology initiative that followed VHSIC was SCP. SCP was a $10 billion dollar undertaking and was DARPAs largest program thus far. This effort supported the development of IT technologies such as Very Large Scale Integrated (VLSI) microelectronics, computer parallel processing, and Artificial Intelligence (AI). From this, commercial innovations include; Computer vision systems,

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[35] Fong., 163-165.

[36] Ibid.

[37] Ibid., 163-165.

[38] Ibid.

[39] Ibid., 166.

[40] Ruth M. Davis, "The DOD Initiatives in Integrated Circuits," *IEEE Computer* (July 1979): 79.

[41] Fong, 167.

speech recognition, and computer based problem solving. Military innovations include robotic vehicles, spoken alerts and natural language interface for flight systems, and the Naval Battle Management System (NBMS).[42]

In the late 1980s and the early 1990s, a significant transition occurred in development planning at DARPA. The emphasis shifted to a more even development ratio between commercial and military innovative development. In some cases, the development planning favored commercial over military competitiveness. This shift was an explicit attempt to address the concern over U.S. global technological competitiveness, specifically with German and Japanese semi-conductor industries.[43] In response to global competition, DARPA initiated the SEMATECH, AL, and HPCC projects. An interesting observation was the subsequent DOD acquisition and MILSPEC reform process following DARPA's commercial reorientation. This is indicative of U.S. technological competitiveness becoming a priority to ensure continued military access to advanced technology within the U.S. commercial market, or spin-on technologies.[44]

The SEMATECH initiative addressed growing concerns over U.S. defense firm's dependence on foreign semi-conductor technologies.[45] This initiative was in direct response to the erosion of U.S. and an increase in Japan's semiconductor industry.[46] SEMATECH began with a consortium of U.S. firms to explore ways to ensure continued R&D, low cost and flexible production, and for sustained U.S. leadership in semiconductor technologies.[47] The commercial consortium took priority over military objectives as emphasis shifted to ensure a stable U.S. technology industrial base that would provide long-term military access.[48] With this strategic approach, SEMATECH

[42] Saul Amarel, "AJ Research in DARPA's Strategic Computing Initiative," *IEEE Expert*, 6:3 (June 1991): 7-11; Fong, 168-169.

[43] Fong, 171.

[44] Ibid., 175-179.

[45] Ibid., 177.

[46] Ibid., 176.

[47] Ibid.

[48] Ibid., 177.

mirrored Japan's Ministry of International Trade and Industry (MITI) semiconductor initiatives that focused on Japan's semiconductor competitiveness.[49] It is interesting to note that SEMATECH was commercially funded after 1995.[50]

In the 1970s, the Defense Department had a large demand for integrated circuits. This demand spurred new techniques for creating smaller circuit design. Soon however, commercial demand would catch up and exceed military demand.[51] From this demand another dual-use DARPA project was created called Advanced Lithography (AL). AL was instrumental in developing both commercial and military micron circuit design. Advanced lithography led to the creation of microcircuits on silicon chips, advancements in which produced significantly smaller circuit production.[52]

> This task builds on previous success and expertise in extending the performance of optical lithography toward deep sub-exposure wavelength features and pitches. The objectives of this task are to: (1) develop new concepts, which allow practical and cost-effective extensions of optical lithography to sub-35-nm half-pitch, (2) work with industry to commercialize those technologies to help U.S. industry retain leadership in deeply scaled CMOS technologies, and (3) understand fundamental limits of lithography.[53]

The early 1990s brought the end of the Cold War and two more initiatives geared toward producing dual-use technologies. The HPC and the Flat panel display initiatives were undertaken for many of the continued commercial technological competitiveness concerns addressed in the SEMATECH and AL projects.[54]

The HPC initiative was divided in two different research and development objectives. One objective focused high performance computing toward the research into

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[49] Fong, 177.

[50] Ibid.

[51] DOD, "Report of the Defense Science Board Task Force for the Investment Strategy for DARPA," Office for the Under Secretary of Defense for Acquisition and Technology, Washington, D.C. (1999):23.

[52] Fong, 170.

[53] DARPA website, http://web-ext2.darpa.mil/mto/programs/amtp/index.html (accessed March 2007).

[54] Glenn R. Fong, Breaking New Ground or Breaking the Rules: Strategic Reorientation in U.S. Industrial Policy*, International Security*, 25:2 (2000): 153.

gene research, digital anatomy, ocean modeling, ozone depletion, and planet imaging.[55] The other focused on electronic commerce, information infrastructure services, manufacturing process modeling, and semiconductor manufacturing.[56] Even with a clear commercial orientation, 40 percent of funding still focused on military related objectives.[57]

The National Flat Panel Display Initiative (NFPDI) was an extension of the SEMATECH program, "a model for federal consortia to advance other critical technologies."[58] With only four percent of the global flat panel market, the United States strategically needed this initiative to stay competitive and maintain military access. With national government leadership interested in strategic economic concerns and DOD military objectives, it created a formidable synergy. Examples of this are the advanced flat panel technology, such as liquid crystal, used in numerous military requirements such as modern jet aircraft cockpits and modern warships' Combat Information Centers. Commercial industries include robotics, ceramics, electronic packaging, lithographic technologies, and electromechanical systems.[59] At the executive level of the United States, the NFPDI represented the model in which to advance U.S. companies' commercial global market position.

Conversely, the national ATP and NNI programs operate outside the Department of Defense (DOD) jurisdiction managed by the Department of Commerce and the Nano Science and Technology Institute (NSTI), respectively.

> The ATP program spurs its partners to invest in research and development that have payoffs far beyond private profit, bringing to Americans higher paying jobs, better consumer products, improved health, greater efficiency, and a cleaner environment….ATP accelerates the development of new-to-the-world technologies by sharing the cost and the risk with companies when research risks are too high for the private sector to bear

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55 Fong, 174.

56 Ibid.

57 Ibid.

58 William J. Clinton and Albert Gore, Jr., *Technology for America's Economic Growth: A New Direction to Build Economic Strength*, February 22, 1993, 9.

59 Fong, 175.

> alone….ATP catalyzes companies, universities, research organizations, and state and local entities to partner creatively to develop innovative technologies….ATP encourages companies to publish and share their results and to pursue patents and licensing to give others a chance to benefit from new knowledge created in ATP projects.[60]

Unfortunately, the ATP program was cancelled in 2007. The "America Competes Act," which focuses the United States efforts to be ready for the "gathering storm" approaching the United States, replaced it. Much of this program focuses on research, science and education. Until this point, this was the only government-sponsored program developed for strictly commercial competitiveness.[61]

However, a new frontier technology appeared with the potential to revolutionize technology. This new technology, called nanotechnology, is of such high importance that the U.S. government implemented a national commercial initiative to research it. The National Nanotechnology Initiative (NNI) "provides a multi-agency framework to ensure U.S. leadership in nanotechnology that will be essential to improve human health, economic well being and national security. The NNI invests in fundamental research to further understanding of nanoscale phenomena and facilitate technology transfer."[62]

To understand the security and economic dynamics throughout these phases of technological initiatives, it is necessary to analyze the implications the end of the Cold War had on defense spending, R&D, and globalization. One problem for the United States after the Cold War military buildup was excess industrial production capacity left in the military industrial complex when it abruptly ended, "Many plants are too large to operate efficiently at post-Cold War production levels of demand."[63] This led to increasing costs for U.S. military hardware. Today this capacity overhang, which produces "legacy" systems, designed for the Cold War has been difficult to end. "Not one

[60] National Institute of Standards and Technology, Advanced Technology Program (ATP) http://www.atp.nist.gov/atp/charter.htm (accessed October 2007).

[61] Fong, 153, 154.

[62] National Nanotechnology Initiative, http://www.nano.gov/index.html (accessed October 2007).

[63] Fong, 154.

Cold War weapons platform line has closed in the United States."[64] The United States, owning the largest share of the worlds GDP and R&D without USSR competition, felt it necessary to flatten its military budgets. This budgetary position has resulted in lower procurement levels and relatively flat R&D levels throughout the 1990s.[65] Additionally, U.S. industry contribution to the total U.S. R&D has dramatically overtaken DOD funding during the 1990s.[66] (Figure 1). This evidence supports the need for an expanded U.S. commercial technology policy led by government spending.

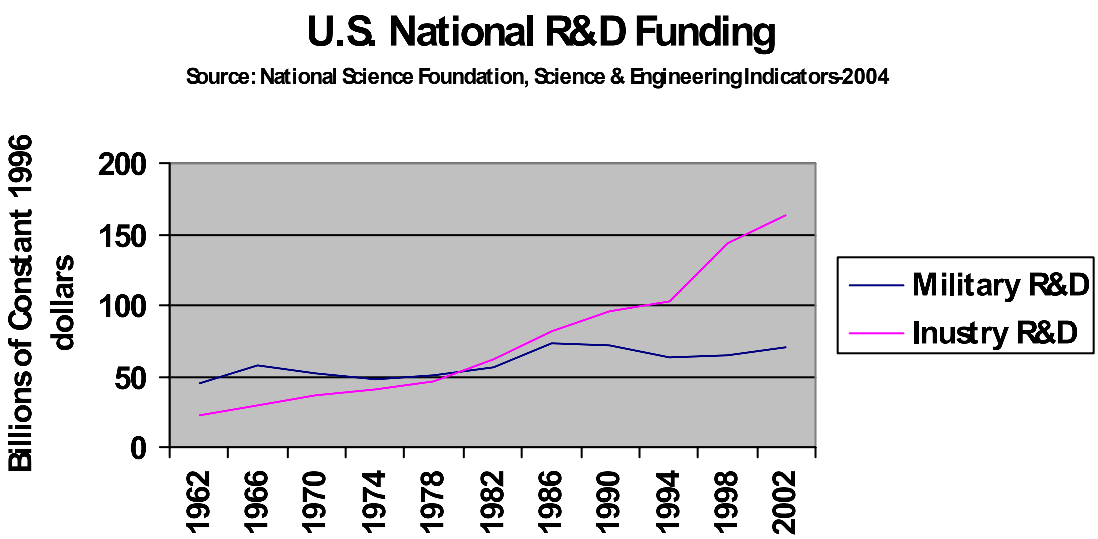

Figure 1. U.S. National R&D Funding

With defense firm over-capacity and a shift to a more commercial R&D funding trend, the DOD decided to reform its acquisition process to accommodate the open market and take advantage of more commercial technology. This reform intended to correlate military standards to its relative commercial standard equivalent.

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[64] Gholz and Sapolsky, 5.

[65] Ibid., 5-8.

[66] Fong, 184.

> During the Cold War, the formative period of the current export control regime, the military drove much technical research and provided funds for research and development. Now that situation is largely reversed. Shrinking defense budgets have reduced funds available for R&D. The military now purchases many items 'off-the-shelf' and relies to a greater extent on commercial applications.[67]

The main target in this reform was to reduce the dependency on the military specification to satisfy military technology requirements. In 1994, the DOD initiated Military Specification (MILSPEC) reform. This reform was in essence a relaxation on custom military technological specification to include non-governmental (commercial) technological specification. MILSPEC reform had several objectives, including elimination of non-essential and military custom requirements and procedures, to take advantage of commercial technological innovation and processes, and facilitate defense firms' commercial diversification, and to lower procurement costs.[68] This would help meet the U.S. national security requirements by enhancing the efficiency and effectiveness of the transference of state of the art technologies from the U.S. commercial industrial base to spin-on military technologies.[69]

With new performance standards, the DOD would rely more on commercial firms to figure out how best to use technology to meet the stated performance requirements.[70] Many specific technological examples provide proof positive of the extent of the non-governmental and performance based standardization reform process. Today, much of the Navy's newest Aegis weapon system is comprised of COTS technologies (see Table 1.). With this integration of commercial off-the-shelf technology into the Navy's most advanced weapons systems, it is clear that maintaining U.S. commercial competitiveness and control of technology is of vital importance to the U.S military. Additionally, the Air Forces' Common Large Area Display Set (CLADS) is another example of COTS

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67 CRS, *The Export Administration Act: Controversy and Prospects*, RL30689, 2003, 2.

68 ASTM Standardization News, "MilSpec Reform: Completed," An interview with Gregory E. Saunders, Defense Standardization Program Office, 2001, 1, 2 http://www.astm.org/SNEWS/NOVEMBER_2001/saunders_nov01.html (accessed February 2007).

69 Defense Standardization Office, "MilSpec Reform Final Report: An Ending a New Beginning," DOD, Washington, D.C. (2001): 1.

70 ASTM Standardization News, 1, 2.

technology used in their E-3 AWACS, E-8, C-130, and ground commands. This technology has reportedly saved 100 million dollars per year.[71] Commercial technology allows Army soldiers and Marines to use wearable ruggedized field computers to increase situational awareness by connecting them to a network-centric battle-space.[72]

COTS suppliers and components in the Aegis SPY-1D(V) radar Source: Military and Aerospace Electronics Magazine @ http://mae.pennnet.com/Articles/Article_Display.cfm?Section=Articles&Subsection=Display&ARTICLE_ID=180882	
Company	**Solution**
3COM, Cabletron, Cisco, Interphase, PTI, RAMIX	Network Technology Solutions
Barco	Video Display Systems
Concurrent, Hewlett Packard, Sun Microsystems, Motorola	Computing Equipment and Operating Environments
Datum	Time Processing
Mountain Optech, Red Rock Tech., Seagate, Sony	Storage Devices
Lantronix, SBE	Terminal Server Technologies

Table 1. COTS Suppliers and Components in the Aegis SPY-1D(V) Radar

However, not all reform areas are working perfectly. The dynamic global technological market has significantly changed since the original premise of the reform process. The U.S. military is not the only global customer in the global technology market. One problem that has caused concern is in life-cycle support. With the U.S. military equipment relying on COTS equipment for vital systems, they are subordinate to global market's innovative demand trends. If the global market no longer demands a specific technology used in military systems and no life-cycle support exists, the military must endure most of the re-design costs.[73] Life cycle support is an ongoing issue being

71 ASTM Standardization News, 14, 15.

72 Military Embedded Systems, "General Micro Systems Introduces, Full Featured High Performance PC for Military Manpack Applications" (2006) http://www.mil-embedded.com/news/db/?2873 (accessed January 2007).

73 Craig Brandenburg, "US Navy COTS: A Double Edged Sword," Navy Sea Systems Command NDIA Conference (October 22-25, 2001): 1.

worked out which requires much more commercially coordinated defense design planning. This demonstrates the volatility of innovative technologies on security requirements and the importance of maintaining a dominant controlling market position. While manufacturing costs have decreased due to the lower cost of commercial manufacturing, design, and R&D, the product line is still dependent upon the commercial global market.

In order to sustain competitive cost reduction in technology development and production, many U.S. technology companies have off-shored production and even R&D abroad in such countries as China. In 2004, China was the third largest location for U.S. firm R&D in Asia behind Japan and Singapore (see Table 2). U.S. affiliates with majority ownership employ over 273,000 employees, and 71 percent of its production is sold to China's growing domestic market.[74] Some notable U.S. high technology companies involved to this extent include IBM, Intel, Lucent Technologies, Sun-Microsystems, and Advanced Micro Devices (AMD).[75] Along with these companies come large investments; U.S. investment in China has increased substantially from 1994 to 2001. Several factors contribute to this trend: China's low cost R&D, government support, low cost materials, and quality and quantity of science and engineering graduates.[76]

U.S. R&D Investment in Asia 2004
Japan $1,740 million
Singapore $711
China $622
Australia $471
Taiwan $363
Malaysia $301
South Korea $246

74 Patricia S. Pollard, "National Economic Trends: U.S. Production Abroad," Federal Reserve Bank of St. Louis (2004) http://research.stlouisfed.org/publications/net/20040601/cover.pdf (accessed October 2007).

75 IBM, Intel, Lucent Technologies, Sun- Microsystems, and Advanced Micro Devices (AMD) Websites.

76 Jules Duga and Tim Studt, "Globalization Alters Traditional R&D Rules," *R&D Magazine* (September 2006): 5.

U.S. R&D Investment in Asia 2004
Hong Kong $220
India $163
Philippines $44
New Zealand $25
Thailand $23
Indonesia $4
Total (world) $27,530 million
Source: The Business Times

Table 2. U.S. R&D Investment in Asia 2004

Another important area of U.S. technological development revolved around its level of control. The United States used export control regimes to ensure its technological innovations did not fall into the wrong hands. This control had an evolutionary path stemming from the Cold War and evolving with its demise and the growth of globalization. Strictly adhered to export control regimes during the Cold War kept technology diffusion or technology transfer from reaching U.S. enemies such as the Soviet Union and China.[77] The main regime was the Coordinating Committee for Multilateral Export Controls (COCOM) established in 1949 by the United States and its allies.[78] The primary motivating factor for COCOM members was the fear of weapons related technologies falling into enemy hands, mainly from target states such as the Soviet Union and China, and returned as weapons used against them.[79] Scholars argue that COCOM worked because it was a "collective response to a common threat or coercion by the dominant state."[80] The dominant state was the United States in the bipolar order created by the Cold War.[81] Following the end of the Cold War, and

[77] Michael Lipson, "The Reincarnation of COCOM: Explaining Post-Cold War Export Controls," *The Nonproliferation Review* (Winter 1999): 33, 34.

[78] Lipson, 31, 32.

[79] Ibid., 31.

[80] Stephen M. Walt, *The Origin of Alliances* (Ithaca, NY: Cornell University Press, 1990); Charles Kindleberger, *The World in Depression, 1929-1939* (Berkeley: University of California Press, 1973); Robert O. Keohane, *After Hegemony: Cooperation and Discord in World Politics* (Princeton: Princeton University Press, 1984).

[81] Lipson, 42.

associated bipolar order, COCOM members agreed a new export control regime was needed to better promote global economic growth. The United States felt it important for Russia and China to have the opportunity to transition to a market economy.[82] So, in 1994, COCOM was replaced with a more inclusive multilateral export control agreement reached in Wassenaar, Netherlands, known as Wassenaar. This agreement promoted transparent individual state policies to prevent "destabilizing accumulations" of conventional and dual-use technologies.[83] Wassenaar was ratified in 1996 after long export negotiations with member state Russia.[84] Wassenaar was a much weaker control regime that relied on member countries' honor system of sorts.

> Under Wassenaar rules, decisions are made at the national discretion and no veto exists in any case. WA also lacks the level of ongoing consultations that characterize COCOM…The emphasis of WA is on nonproliferation, transparency, and end-use assurances, rather than wholesale denial of technology and trade to Communist states.[85]

Wassenaar provides a nondiscrimination membership, or conditionally open to member states. The only states formerly tagged as target states were Iran, Iraq, North Korea, and Libya.[86] Wassenaar critics have argued that it only provides a forum for collecting data on particular technology transfers, and its weakness provides the impetus for the United States to institute unilateral export controls.[87] However, others argue that the Wassenaar regime is a natural progression of states moving into a more globally interdependent structure where the cost of trade wars far exceeds the benefit of controls. Additionally, "the United States no longer has the sort of global economic and technological dominance it once commanded in the early decades of the Cold War."[88]

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[82] FAS.org, USIS: Washington File, Text: State Dept.'s Holum on Multilateral Export Controls (2000) http://www.fas.org/nuke/control/export/news/000412-export-usia1.htm (accessed October 2007).

[83] Lipson, 38, 39.

[84] Ibid., 42.

[85] Ibid., 40.

[86] Ibid.

[87] Ibid., 41.

[88] Ibid., 43.

However, the reason why the Cold War ended and the Soviet system collapsed is the diffusion of normative values favoring multilateralism, and Gorbachev identifying with the liberal West.[89] With this, the Wassenaar regime, and other inclusive multilateral policies provide opportunities to increase social interaction, closer common identities, and normative values. Therefore, China should be included into this membership with the intention of creating a shared social intersubjective of how proper liberal states behave, and how they understand and solve problems.[90] "Engaging the Chinese at an early stage of the regime development process lay a promising foundation for future compliance with international norms."[91] Moreover, if Wassenaar is ever to become the robust and effective regime envisioned by its members, it would need to be a collaborative problem solving effort rather than merely promoting transparent policies to help avoid an inevitable common threat.[92]

2. China's Development Path

China is now considered by many security minded professionals in the United States as the next great-power competitor with the United States.[93] Central to the accuracy of this prediction will be China's military technology modernization plan called the "863 program" that was put into effect in 1986 and China's rising military budget to meet this end. After missing the technology boom advancing through the United States in the late 1960s and 70s, China's technological base was roughly 15 years behind the United States by the 1980s.[94] Chinese S&T processes were flawed and needed reforming. Although Chinese leadership had placed greater emphasis on S&T initiatives, in 1978 the military engineers realized they could not compete or keep pace with the dynamically

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[89] Koslowski and Kratochwil, "Understanding Change in International Politics," 219; Michael Beck, "Russia's Rationale for Developing Export Controls," in Bertsch and Grillot, *Arms on the Market*, 42.

[90] Lipson, 45-47.

[91] "Fresh Start for Wassenaar," *Intelligence News-letter*, September 3, 1998.

[92] Lisa L. Martin, *Coercive Cooperation: Explaining Multilateral Economic Sanctions*, (Princeton, NJ, Princeton University Press, 1992).

[93] Adam Segal, "Practical Engagement: Drawing the Fine Line for U.S.-China Trade," *The Washington Quarterly,* 27:3 (2004), 157-158.

[94] Feigenbaum, 98.

advancing global technology primarily controlled by the United States.[95] With prolonged external stability, China focused on a domestic economic development national strategy. Faced with shrinking budgets, Chinese defense elites realized “given the growing interdependence between defense technology and commercial innovation, strategic leaders soon took the position that China’s national R&D system, not its defense-technical systems, was the real issue at stake.”[96]

Accordingly, there began a big push in China for a national R&D program that would satisfy both commercial and military needs. The 863 programs develop a state centric strategy for long-range leading edge technology development to foster both industrial competitiveness and military strength.[97] “The program transitioned from a weapons systems era model of spin-off to a subtle, if more technical broad ranging, effort at commercial-to-military ‘spin-on’ technologies.”[98] The implication of this was that Chinese defense planners knew that defense requirements were becoming a function of the commercial market and adapted their requirements to take advantage of the global market and technology transfers.

There was strong emphasis on the 863 Program for acquiring the latest technology in order to modernize commercially and militarize China more effectively. “The 863 effort reflects a continuing-and almost reflexive-fascination with the ‘latest’ technology that belies the huge gaps continuing to China's industrial base.”[99] This is tantamount to the “leap frog” approach so often referred to as a key factor in China's technology catch up strategy with the West. China is using a national strategic technology policy (863) and is not taking a laissez-faire approach. The United States should implement its own strategic technology policy that takes full advantage of its innovative lead in existing and pioneering technologies.

95 Feigenbaum, 100.

96 Ibid., 101.

97 Ibid., 113.

98 Ibid., 122.

99 Ibid., 124-125.

The 863-technology development plan was not a linear evolution but one that took shape over two decades of policy experiment. This program coincided with or perhaps fostered the process of globalization with its associated Foreign Direct Investment (FDI) and Foreign Invested Enterprises (FIEs). The plan was initially limited as a techno-nationalist plan that selectively limited access to Multi-National Corporations (MNCs), and centered on State-Owned Enterprises (SOEs) and government sponsored research.[100] China believed that these selective SOEs could cooperate with selective MNCs and would successfully diffuse technology domestically. However, an inefficient and ineffective bureaucratic structure coupled with limited entrepreneurial, technical, and global business experience kept China from realizing this goal.[101]

Throughout the latter half of the 1980s and into the early 1990s, the 863 plan was of limited success due to this restrictive market philosophy. One area in China, the Guangdong province, however, was having great success with FDI. This province allowed a much more independent corporate operation allowing greater access to MNCs through Hong Kong. This access fostered a multi-national cooperative technological relationship that in turn, fostered a more global business experience.[102] The success in Guangdong province provided the impetus for a more liberal 863 policy that relies on FDI and individual entrepreneurial experience.[103]

In 1993, a decision allowed Non-Governmental Enterprises (NGEs) to play a key role in technological development in China. "Innovative systems based on market-oriented technology forms as well as changing S&T systems dominated by public institutions to one that embraces organizations of various ownership structures."[104] This policy change increased global business cooperation that in turn increased FDI, as well as FIEs. By 1997, MNCs became the primary source of technology imports into China.[105]

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[100] Barry Naughton and Adam Segal, "Technology Development in the New Millennium: China in Search of a Workable Model," *MIT Japan Program* 1:3 (2001): 6, 7.

[101] Ibid., 8, 9.

[102] Naughton and Segal, 9, 10.

[103] Ibid., 10, 11.

[104] Ibid., 6, 7.

[105] Ibid.

This new liberal policy increased high technology exports and opened up China's huge domestic market to a globally interdependent technology trade. China would now recognize private domestic enterprises and FIEs as a vital component to its development strategy.[106]

Implications stemming from political change after the Asian Financial Crisis of 1997 cemented the end to policies that relied on SOEs and instead shifted toward encouraging start-up, small business, and venture capital. The Chinese government, for the first time, "fully acknowledged the legitimate contribution and equal rights of private enterprises." China now considered these firms "national" assets or "national champions" as it did of SOEs previously.[107] There was also a recognition of the innovative contribution disenfranchised Chinese scientists had made in the United States. These new policies were conceived to keep Chinese scientists from working abroad by creating incentives and supporting their innovative capacity. By 1999, the government's ability to select specific technology imports had diminished. A new broader emphasis placed importance on encouraging the diffusion of knowledge through less tangible means such as consulting rather than hard-pressed "hardware" transfers.[108]

With growing venture capital, entrepreneurial growth, and expanding private firms, the 863 policy shifted again to promote domestic technology development. The implementation of new incentives to foster the budding entrepreneurial spirit had begun. These incentives were specific in support of domestic high tech industries and services. Other implementations included many generous funds, tax deductions, and exceptions to encourage the transfer and or development of new technologies.[109] Additionally, high technology companies had the opportunity to list on the Shanghai and Shenzhen stock exchanges. These incentives combined with low cost labor and a large domestic market provided China with a significant comparative advantage that fosters the growth of domestic technology enterprise as well as multi-national technology corporations and

[106] Naughton and Segal, 12.

[107] Ibid., 15, 16.

[108] Ibid., 16, 17.

[109] Ibid., 17.

their associated foreign invested enterprises. Due to liberal policy reform, annual inward FDI increased from $11 billion in 1992 to $70 billion in 2005 (see Figure 2). In general, this FDI shows China's growing interdependence with the West.

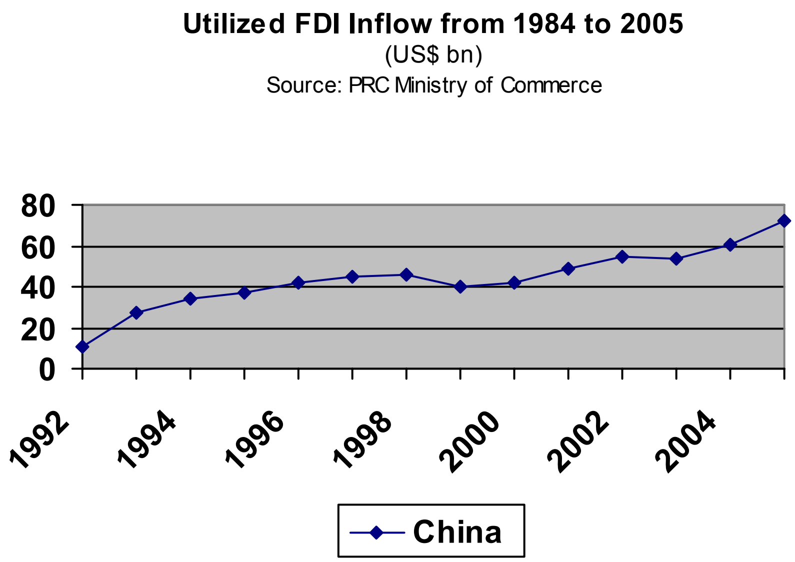

Figure 2. Utilized FDI Inflow from 1984-2005

The Chinese Huawei firm provides examples of successful domestic enterprise during this time. The Huawei telecommunications equipment company started out taking advantage of the special economic zones that allowed collaboration and cooperation with foreign firms and capital. "Huawei is entirely Chinese and with national reach. In 1999 revenue from this telecommunication switch maker reached U.S. $1.8 billion."[110] Huawei is employee owned (joint stock), highly educated (80 percent with upper level degrees), and invests heavily in R&D (18 percent of revenue).[111] It is just one example of the new independent entrepreneurial enterprises springing up in China and shows the potential for even more sophisticated domestic technology companies to emerge. However, Huawei has been known to steal technology secrets by disassembling, copying,

[110] Naughton and Segal, 18.

[111] Ibid., 17.

and reverse engineering equipment of competitors. This was the case when Huawei settled complaints of such violations of copying from Cisco, a U.S. software company.[112]

Another example is the Legend Company started in 1984 by a group of scientists from the Institute of Computer Technology (ICT) at the Chinese Academy of Science (CAS). It began by developing Chinese character conversion technologies for PCs used in China. By 1998, they were producing their own PCs sold in China's domestic market.[113] Legend's modern organizational structure would become the model to emulate in China.[114] Legend (now renamed Lenovo) diversified to include scientific research in networks, software, and microelectronics.[115] From 1993 to 1997, Legend's profits went from $500 million to $1.5 billion. In 2000, Legend became a joint-stock company with CAS as the largest stockholder.[116] Today, China's private high technology companies such as Legend, as well as others like Great Wall, and Langchao, all find their origins traced back to government 863 funded initiatives.[117] Huawei and Legend represent just two Chinese owned companies taking advantage of China's new more liberal technology development policies. Low operating costs, government incentives, and a plethora of inexpensive but highly qualified physicists and scientists factor favorably for domestic technology companies to continue to grow in China. Companies like these in China must be recognized as potential diffusers of Western technology that have the potential of becoming direct competitors in high technology innovation. As one high-ranking Chinese official from the Shanghai Science and Technology Bureau states, "Future conflicts may well be competition for the possession of knowledge. Now all the most valuable intellectual property is in the hands of the Americans. That's not right."[118]

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112 James A. Lewis, "Building an Information Technology Industry in China: National Strategy, Global Markets," *Center for Strategic and International Studies* (May 2007): 8.

113 Ibid., 18.

114 Ibid.

115 Ibid.

116 Ibid.

117 Ibid., 6.

118 Ibid., 7.

Additionally, the Chinese government takes direct action to support core technologies within the 863 program. This techno-nationalism is ongoing, "The state will support each year, through interest subsidies, a few technological restructuring projects by large or medium-sized state owned enterprises that are deemed to be profitable, of strategic significance and merit on scientific ground."[119] Thus, the techno-nationalist policy is still relevant and so equates the 863 plan to a hybrid policy that combines elements of both liberal market forces and state planning. Nevertheless, the government realizes that the only hope of staying in power is to maintain economic and technological development. This understanding makes successful market competition a very powerful policy-shaping tool in China.

> Chinese policy, while still attempting to shape market outcomes, is now to a significant extent itself shaped by market processes. The government did not choose competitors, but elected to support aggressive competitors once they emerged….The most successful parts of China's technological development in recent years appears to be precisely the areas where innovative domestic firms are closely related to FIEs, but engage in complex relations of supply, cooperation and competition…This seems to have led to a rapid 'indigenization' of technological competencies…The shift in policy seems to recognize the successes that are being achieved by China's more entrepreneurial domestic firms, and could position China well to take a larger share of the ongoing technological revolution.[120]

With all of the economic synergy brought about by growing global enterprises based in China, security remains a concern. From the 1991 Gulf War, Kosovo Conflict, Taiwan Straights Crisis, and the EP3 accident, comes a great concern of U.S. military dominance. After the first Gulf War, China's leaders proclaimed, "We should attach great importance to strengthening the army through technology, enhance research in defense-related science . . . give priority to developing arms needed for defense under high-tech conditions, and lay stress on developing new types of weapons."[121] During the Taiwan

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119 Naughton and Segal, 18.

120 Ibid., 19, 20.

121 Feigenbaum, 126.

crisis, China's leadership linked a "sound base in technology and national defense to the success of mainland's re-unification enterprises."[122]

China is also not without the ability to leverage its market capital as a means of providing economic disincentives as it did when it decided to buy Airbus rather than Boeing aircraft. This decision was likely to punish the United States for its policy supporting the status quo with regard to Taiwan's status.[123] The precarious position China still finds itself in by being dependent upon external technology continues to put pressure on China to ensure a higher degree of technological diffusion. With such technological independence, China is still vulnerable to outside influence over its foreign policy. China's leaders when championing domestic technological innovation and market dominance point this out.[124]

China's market size has security implications due to the leverage it can wield due to its economic advantage. As China's domestic market continues to grow in size and purchasing power, it will also gain greater ability to shape global technologies. This would give China a distinct advantage in emerging technological market. The huge domestic market demand for specific technological innovations has the potential to set new global standards that equates to a competitive advantage.[125] If China is able to dominate in strategic global trade, it could develop its own standard that could possibly position it to control pioneering technologies even as its domestic market continues to grow.[126] This is more evidence the United States needs a strategic technology policy to keep these important standards within the borders of the United States.

China has focused much effort in improving its ability to research and develop new technology, "China has surpassed both the United States and India in advanced

[122] Willy Wo-Lap lam, "Jiang Boosts Defense Funding," *South China Morning Post,* December 1, 1999.

[123] Naughton and Segal, 20.

[124] Ibid., 21.

[125] Ibid., 21, 22.

[126] Ibid., 23.

engineering and technology degrees, as well as in conducting basic research."[127] This demonstrates China's dedication to education, particularly in engineering. However, even with China's highly educated workforce, it has relied on technology transfers for much of its innovative technological developments. Such was the case when in the mid 1990s China gained access to sensitive technology from the United States. The implications from this illegal technology transfer will be discussed further in the next chapter. With so many FIEs allowing collaboration with foreign counter-parts, it is only a matter of time before the line is crossed and permanent diffusion of technological processes and knowledge allows continual innovation to takes place. This innovation of course then can be diffused militarily. This is what the security minded in the United States fear from a rising China being able to use the very technology the United States helped develop against it in war or conflict. Nevertheless, the question is, what can the United States do, realistically, to mitigate this fear in an evolving global economy.

B. CONCLUSION

Technology plays a key role in process of globalization, economic competitiveness, and security. It is only logical that it should play a key role in the foreign and trade policy with China.[128] The two distinctly different technological development paths taken by the United States and China necessitate some important observations. While the United States' trade policy has fostered maintaining its broad technological lead, China's policy is one, which seeks to catch up or "leap frog" over the competition. China has used global trade, FDI, and its relative advantage of inexpensive but highly educated workforce in combination with an aggressive 863 plan to achieve this goal. This plan has brought much high technology investment from the United States. As this investment continues to grow, a technological trade synergy between the United States and China becomes apparent. Moreover, U.S. MNCs benefit by being able to

[127] Zeesnews.com, China offers more engineering graduates than India, US, http://www.zeenews.com/articles.asp?aid=360728&sid=NAT&ssid= (accessed January 2008).

[128] J. Thomas Ratchford, "Put Science and Technology Back into Foreign Policy," *Science* 282:5394 (1998): 1650; Timothy E. Wirth, Irving A. Lerch, and Peter A. Cohen, "Science, Technology, and Foreign Policy," *Science* 277:5330 (1997): 277, 278.

research collaboratively, design, and produce relatively inexpensive innovative technologies which quickly sale on the global market. This profit also fosters more foreign investment in China. The U.S. and Chinese consumers also benefit with inexpensive innovative products. Another equally important aspect is the effect of globalization on maintaining U.S. market control with respect to providing U.S. military technological advancements in the era of COTS. The U.S. commercial sector must strategically position itself to remain the technological innovative leader. "The underlying IPE of US-China relations paint a picture of deepening levels of interconnectedness that, if viewed in terms of US structural power over ideas and institutions at the global level, benefit the stronger partner."[129] The United States maintains a dominant economic position in this synergistic economic relationship, "Another structural factor maintaining the US's dominant position over China is attributable to the fact that China remains a developing country hugely reliant on the import of US technology and expertise."[130] The United States can ill afford economically to approach China in the same way it approached the Soviet Union during the Cold War. The Soviet Union was in economic isolation with most of the West and so the United States could afford to conduct economic warfare through the implementation of vigorous control regimes such as COCOM. This is not the case with China where the repercussions of such economic warfare seems would not only to be infeasible but economically self-defeating. There is a view that one factor that caused the Soviet Union to collapse and lose the Cold War was due to its economic system's inability to adapt and compete in the global technological marketplace.[131] Will the United States succumb to this same fate when technologically competing with China in the GPE?

There is a need to carefully balance economic demands with export controls due to the vital linkages between U.S. - China economic interdependencies, and U.S. military's dependency on commercial technological competitiveness for spin-on

129 Mark Roden, "US-China Relations in the Contemporary Era: An International Political Economy Perspective," *Politics* 23:3 (2003): 197.

130 Ibid.

131 David Lockwood, The Destruction of the Soviet Union: A Study of Globalization, (Macmillan, Basingstoke, England 2000): 24-128.

technologies.[132] It is plausible that the dependency on the United States for technical innovative development has provided beneficial influence over China. Access to U.S. technology comes by way of liberal market institutional norms and standards. Allowing China to join the World Trade Organization (WTO) in 2001 was contingent upon it institutionalizing trade practices and opening its market.[133] The world bet on reciprocity, measured compliance, and sanctioned retaliation to provide incentive for proper state behavior. Therefore, while China has benefited from global trade access, it has fallen in line with U.S. trade standards and practices, which enhances U.S. GPE standing.[134] Positive state behavior is not limited to exposure to liberal trade norms and standards alone. Another equally important aspect is the product and engine of trade itself, technological innovation, which plays a role in shaping new ideas, understandings, and innovations. Technological innovation can enhance ideas, communications, problem solving, and understanding, all of which are vital components of a successful foreign policy apparatus.

In order to find balance between economic and security concerns, the United States government should implement a new collaborative technology initiative with the same effort it had taken during the Cold War. This new technology initiative would be focused to address the growing concerns over China' rising economic and military competition with the United States. China already takes advantage of an aggressive and progressive technology policy, thus the United States should as well. This new initiative would incorporate a new collaborative approach to technology research and development as well as export controls. Export control would be an integral part of the collaborative technology initiative, and overall collaborative-engagement policy, designed to ensure a strategic approach is used to control the export of sensitive dual-use technology.

An important question with regard to this scenario, and the main research for this thesis, is to understand the current export controls and its weaknesses better. From this, what type of export control mechanism or policy changes are needed if any? The next

132 Roden, 192, 193.

133 Ibid.

134 Gerald Segal, "Tying China to the International System," *Survival* 37:2 (1995): 60-73.

chapter will study two cases involving illegal technology transfers from the United States to China in the mid to late 1990s. By studying these two cases, made famous by the Cox Report that recommended stricter export control measures, the effectiveness of export controls to limit the technological development in China as well as maintaining U.S. technological competitiveness within the GPE structure will be determined. In 1998, the U.S. Congress established the Cox Commission to investigate and report its findings on the unauthorized transfer of sensitive technology to China. This investigation was driven by the concern that China was using U.S. technology to develop its nuclear weapons capability.[135]

[135] Anjali Bhattacharjee, Basic Publications, Politics and Proliferation: Analysis and Summary of the Cox Committee Report and the Allegations of Chinese Nuclear Espionage, http://www.basicint.org/pubs/1999june-coxreport.htm (accessed January 2008).

II. CASE STUDIES: EFFECTIVENESS OF CURRRENT U.S. DUAL-USE TECHNOLOGY EXPORT CONTROL SYSTEM

Well-known cases of militarily sensitive dual-use technology transfers from the United States to China occurred throughout the 1990s. There have been transfer violations in nuclear, encryption, precision machining, high performance computer (HPC), and satellite technologies. This thesis selected HPC and satellite technologies cases because they represent the full spectrum of dual-use technologies that diffuse more easily then more obvious military oriented technologies. While computers are in high commercial demand for many useful benign projects, they can also be used to help build weapons, design weapon delivery vehicles, and enhance tactical knowledge with advanced simulation software. High performance computers are most likely going to be used by government agencies in support of its mission. Satellite technology has a more narrow demand due to its limited commercial adaptability, architecture, and expandability. Satellite technology also has benign utility such as commercial communication, and using satellite imagery of the earth to understand environmental affects of soil erosion, flooding better, etc. This technology could also be used militarily to locate, track, communicate, and target potential enemy targets with the same basic type of imagery. There is also a threat that satellite launch technologies will be used to develop military ballistic missile technologies.

Commercial cost is a primary driver for how broad a technology will diffuse into society.[136] On a scale ranging from the low end of primarily commercial to the high end of primarily military applicability, HPC represents the lower limit or a more benign dual-use characteristic then does satellite technology, which lies at the upper limit. Therefore, these two technologies represent both ends of the dual-use technology spectrum that will be studied to better understand the effectiveness of current export controls. Usually the more benign a technology, the less it is controlled. Less benign technology gravitates to a more security centered export control policy.[137]

[136] Goldman and Ross, 383.

[137] Arquilla, 368.

A. SATELLITE RELATED TECHNOLOGY TRANSFER STUDY

Satellite technology transfer to China has long been a contentious economic and security dilemma. All through the 1990s, the United States struggled to define satellites and associated technology adequately as "dual-use" or "munitions." The resultant policy would split the export control jurisdiction between the State Department and the Commerce Department. The State Department would handle the stricter export controls on the less benign satellite technology deemed munitions, and the Commerce Department would control the exports of the more benign dual-use satellite technology. This arrangement is neither effective nor efficient at facilitating U.S. commercial satellite competitiveness or satisfying security objectives.[138] Additionally, the United States faces global competition from its Wassenaar trading partners, who all interpret satellite technology as dual-use and place no restrictions on their export to China.[139] Additionally, the Wassenaar agreement itself places no controls on satellite technology. These circumstances place a great burden on U.S. export control system that worked well against the single Cold War Soviet competitor. This case study will help determine weaknesses in satellite U.S. export controls.

As part of its 863 plan, China made it a high priority to import dual-use technology for both commercial and military use.[140] It was legal under the U.S. export control laws to export satellite dual-use technology and to take advantages of launch services in China. In the early 1990s, satellite export-control oversight was split between the Department of State and the Department of Commerce, which allowed easing of export controls on the more benign satellite technologies to help bolster global growth of U.S. commercial satellite sales and services.[141] This easing of controls allowed U.S. satellite manufactures to go offshore to China to take advantage of its launch services and

[138] John A. Lewis, Regulating Satellite Exports, Center for Strategic and International Studies (2003), http://www.csis.org/media/csis/pubs/030502 regulating satellite exports.pdf (accessed January 2008): 1-11.

[139] Ibid.

[140] Cox Report, U.S. National Security and Military/Commercial Concerns with the People's Republic of China, Select Committee United States House of Representatives, 1999, Chapters 1, 18.

[141] John A. Lewis, Center for Strategic and International Studies, http://www.csis.org/media/csis/pubs/030502 regulating satellite exports.pdf (accessed January 2008): 3.

lower operating cost.[142] However, it also split security responsibilities and added risk to the export control process. This inability to access the risk associated with certain technologies adequately will be a key factor that shows the inadequacy of the current export control structure.

In 1996, a launch failure at one of China's launch cites required technicians from the U.S. aerospace industry to help troubleshoot the problem with their Chinese counterparts and in the process, passed unauthorized sensitive launch rocket technical details. An encryption chip was also missing from the equipment as well. This was a clear violation of export control laws restricting the passing of encryption, rocket, or missile technical details to China.[143] The rockets used for the satellite launches share many common features as a ballistic missile used for military attacks.[144] The United States restricts this technology from China in hopes of keeping China from being able to develop and perfect ballistic missile technologies. Additionally, the United States prefers to limit such technology in hopes of limiting China's technology advancements, which lowers the risk of a missile attack against Taiwan.[145] The Commerce Department unwittingly approved the illegal transfer of technical data it believed was benign and within its jurisdiction. As a result of this violation, controlling the export of the entire spectrum of satellite technology became the responsibility of the conservative State Department once again. This resulted in a dramatic reduction of exports of U.S. satellites in 1999 and, "diminished the cycle-time advantages the lean, agile US builders had achieved."[146] The U.S. satellite industry had invested heavily in new launchers, but was counting on using Chinese launch services until they recouped their investment and could get the U.S. launch services up and running.[147] Even though the industry suffered

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142 RAND, *United States Air and Space Power in the 21st Century*, Project Air Force, Washington, D.C., (2002): 152.

143 Cox Report, Chapters 5, 3-6.

144 Ibid., Chapters 1, 19.

145 Ibid., 3.

146 RAND, *U.S. Air and Space Power in the 21st Century*, 153.

147 Frank Oliveri, Congress to re-examine tough commercial satellite export controls, http://www.space.com/missionlaunches/fl_satellite_sale_slows_001218.html (accessed January 2008).

economically, it was a success for security minded policy makers and ensured that U.S. missile, satellite and its associated GPS signals remained securely under U.S. control. However, to determine long term economic and security success from this protectionist policy, further analysis is required. This shows how ineffective the current export control structure is at determining both security risks as well as economic risks associated with controlling technology transfers to China. With this set up there seems to be only a blanket policy that is neither efficient nor effective in serving U.S. security and economic needs.

Foreign customers and long-standing allies within the European Union (EU) have questioned the reliability of U.S. technology availability. They tired of technology delays brought about by the inefficient and slow State Department technology licensing process. Consequently, many EU members collaborated to develop their own technological base upon which to rely.[148] Moreover, other countries such as Canada have refused to do business with the United States satellite industry due to restrictive export controls.[149] "By the year 2000 the U.S. share of the geosynchronous satellite market declined from 75 to 45 percent."[150] The burdensome U.S. licensing requirements work to constrain rather than advance U.S. technological competitiveness in the global market.[151] This shows that a more dynamic control mechanism is needed that does not disrupt U.S. commercial competitiveness.

The effectiveness of the current export control system becomes more dubious when factoring new global satellite competition and the ramifications of current U.S. isolation in the satellite industry. In March 2002, the European Council of Transport Ministers gave the go ahead to start the development of Galileo, a European Space Agency (ESA) developed system to rival U.S. GPS based systems. The U.S. Pentagon warned that it creates a potential national security issue due to overlapping frequencies in

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148 James A. Lewis, Center for Strategic and International Studies, http://www.csis.org/media/csis/pubs/030502_regulating_satellite_exports.pdf (accessed January 2008): 1-3.

149 Richard Van Atta, "Export Controls and the U.S. Defense Industrial Base," Institute for Defense Analysis Volume 2 (2007): A-3.

150 Ibid.

151 Ibid.

the military frequency band. "The addition of any Galileo service in the same spectrum as the GPS M-code will significantly complicate our ability to ensure availability of critical U.S. military GPS services in a time of crisis or conflict, and at the same time assure that adversary forces are denied similar capabilities."[152] The United States insisted that a free and open market should determine which system users choose. One of the U.S. concerns was that the EU consortium (ESA) wanted a GPS system independent of the U.S. controlled system. "Europe has long wanted less restrictive U.S. policies regarding access to U.S. market, technology transfer, and third party sales of technology and products."[153] U.S. security concerns centered on the fact that the Galileo project has military capability and operated under civilian control.[154] This situation was further complicated when China entered under contract with the Galileo Joint Undertaking (GJU) in the development phase of the Galileo program. The National Remote Sensing Center of China (NRSCC) will be responsible for the implementation of this program in China. The ESA already has extensive collaboration with China's development of its remote sensing satellite capabilities.[155] A press release from GJU states China had signed three contracts in 2005 for Chinese aerospace industry involvement in the Galileo project.[156] The United States, fearing a loss of market share, worked with the EU to establish a collaborative framework. It appears likely that the U.S. GPS system will remain viable through a collaborative agreement reached by the US and the EU over GPS use.[157] This entire scenario is important because it shows that a strategic export control system that collaborates with allies to keep technology under U.S. control is critical. If the United States had established a collaborative agreement with the EU early, it could have communicated and cooperated with the EU to work through their technology trade policy

[152] AFP, Brussels, 18 December 2001, US Warns EU about Galileo's Possible Military Conflicts.

[153] RAND, *Going Global?: U.S. Government Policy and the Defense Aerospace Industry,* Project Air Force, 2002, Summary XXII.

[154] RAND, *Building a Multinational Global Navigation Satellite System: An Initial Look*, Project Air Force, 2005, 2, 3.

[155] ESA living planet program, Europe and China collaborate on methods of monitoring the Earth's vegetation, http://www.esa.int/esaLP/SEMNONO2UXE_LPearthexp_2.html (accessed October 2007).

[156] Galileo Joint Operable Committee (GJOC), Memo.

[157] RAND, *Building a Multinational Global Navigation Satellite System: An Initial Look*, 66.

differences. This collaborative agreement then could have grown into a greater cooperation in keeping technology from being transferred to high-risk countries such as China. Unfortunately, today, China's launch service has been so busy providing launches for European satellite manufacturers that it drew complaints from the United States.[158] This shows the need for the United States to lead in a collaborative network with the EU, as well as other countries to ensure that U.S. technology remains available and technology controls are standardized under U.S. leadership.

China, which has collaborated with the EU, is now building up its own indigenous satellite capability and future prospects are low for a continued foreign market there. While China moves toward collaboration, Canada and South Korea have shifted away from doing business with the United States satellite industry and toward the EU. Canada has made it clear it will not do business with the United States due to its restrictive export controls.[159] In fact, from 1995 to 1999, while under Department of Commerce control, the U.S. market share was 68 percent. From 2000 to 2006, it shrank to 58 percent under the more restrictive State Department control, as the EU market rose from 19 to 28 percent in this same period.[160] This shows the importance of ensuring that whatever technology is controlled, it will need to have some sort of economic incentive to keep it economically viable.

China's aerospace industry has gained a knowledge base through its collaborative efforts with the ESA, and the potential to develop new satellite technological innovations with probable diffusion throughout its military industry as well. This is evident by China's recent launch of a DF-31 ballistic missile test in 2006, which is capable of hitting some parts of mainland United States with a nuclear payload.[161] This test, coupled with China's recent successful launch of an Anti-Satellite Missile (ASAT) in 2006, provides clear evidence that current U.S. export controls will not keep China from advancing its

[158] Wall Street Journal online, China's Launch Services Makes Inroads, Irks US, http://online.wsj.com/article/SB119154666486349753.html?mod=DAR (accessed October 2007).

[159] Van Atta, A-3, A-49-A52.

[160] Ibid., A-3.

[161] Hans Kristensen, China Test-Launches New Ballistic Missile, FAS.org Strategic Security Blog: A Project of the Federation of American Scientist (2006) http://fas.org/blog/ssp/2006/09/china_testlaunches_new_ballist.php (accessed August 2007).

satellite and ballistic missile technology.[162] The fallout from China's tests of its ASAT and DF-31 program may result in the United States becoming even more restrictive in its global trade with China, and push for new technologies to skirt China's ASAT program. This has the potential for starting a space arms race with China and increasing the potential for a security dilemma driving up regional fears. This fear increases the potential for miscalculation by both China and the United States as they both jockey for relative military superiority in space.[163]

There is no doubt China is advancing its technology, the question is whether or not China would have advanced faster with full access to U.S. technology? The answer is the U.S. can and must do better at preventing less benign satellite technology from diffusing into China's military and at the same time preserving U.S innovative base. It is clear China will use its technological development to build military technology designed to defeat the military technology of the United States, and so it is imperative to address the current export control weaknesses before pioneering technologies begin to evolve.

There are three major weaknesses with the current satellite export-control system. One weakness is it is a U.S. unilateral undertaking. There is no satellite control consensus within the multilateral Wassenaar agreement, which allows Wassenaar members to collaborate with China unabated while the U.S. satellite industry suffers economically. The U.S. and EU in particular need to find consensus and clearly differentiate and address controls of associated satellite technologies, such as launch vehicles, that are often uncontrolled. Another weakness is that there is no connection between developing effective export controls on specific technologies and buffering the economic cost and innovative entrepreneurial loss when implementing those controls. Lastly, and potentially the gravest, is that static political agencies such as the State or Commerce Department fail with efficiently and effectively controlling rapidly evolving and innovating satellite technology transfers to China. The current system makes satellite export controls an after thought and not strategically planned. There is a need to have in

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[162] Kristensen.

[163] Carin Zissis, China's Anti-Satellite Test, Council on Foreign Relations: A Resource for Nonpartisan Information and Analysis (2007) http://www.cfr.org/publication/12684/ (accessed August 2007).

place a system that can adequately determine risk, and apply controls rapidly and effectively but at the same time maintain U.S. commercial economic and innovate competitiveness. Whether measuring success by limiting China's ability to diffuse technology into its military or to keep the U.S. competitive, the current systems of U.S. export controls are inadequate.

> If the intent of U.S. export control policy on Satellite Technology is intended to keep China behind the state of the art, to keep U.S. firms ahead of the rest of the world, or to sustain U.S. industrial capabilities, these policies have failed. If anything, export controls have likely spurred foreign governments to develop their own industrial capabilities and avoid use of U.S. technology.[164]

B. HIGH PERFORMANCE COMPUTER TECHNOLOGY TRANSFER CASE STUDY

Another area of concern for the United States is the transfer of high performance computer technology to China. Even though this technology represents a more benign technology, in that it is more globally available, the United States fears China will exploit this technology and innovate it for military use. Examples of some types would be ballistic and cruise missile development as well as command, control, communications, computers, intelligence, surveillance and reconnaissance systems (C4ISR) technologies.[165] As in the satellite case, the United States relies on an outdated export control system that relies on the State or Commerce Department to monitor and control rapidly evolving technologies. New extremely powerful HPC innovations, such as cluster computing networks, means that no matter how the United States limits exports of individual machines to China, they will be configured or clustered to exceed those controls. The United States made a controversial decision to relax export controls on these computer systems in 1996.[166] This determination centered on the argument that it was not possible to affect export control over this type of technology worldwide, due to

[164] Van Atta, A-88.

[165] Cox Report, Chapter 3, 98.

[166] Ibid., Chapter 3, 100.

its proclivity to quickly be innovative and diffuse.[167] This argument concluded that controllability was mainly associated with market availability and demand.[168] From this conclusion, export controls were relaxed but the Cox Report argued that this conclusion lacked adequate data on how suspect countries like China were using this technology. This was made more complicated by China's refusal to allow verification of HPC intended use or location.[169]

A current analysis on HPC uses in China will help determine the effectiveness of current HPC controls and will determine the validity of the argument about location and use. The current HPC export controls focuses on the computational level required to conduct certain military related processes. Data extrapolation determines where suspect countries risk factors fall within these computational levels, to help determine the appropriate computer computational level suitable for export to that country.[170] The current system uses a three-tiered export control system structured according to the level of security risk posed by individual countries. The higher the tier a country falls, the better the performance of computer exported. Tier one countries get the best performance whereas tier three the worst.[171]

There is no adequate international control regime for HPC technology. The Wassenaar export control regime, which covered associated WMD items, does not have provisions for controlling high performance computers. Moreover, as a result, the number of tier one countries receiving the most powerful computers compared to the tier three countries such as China, is 15 to 3.[172] The probability of re-export and diffusion of technology from a tier one country to a tier three country is probable with this ratio. This becomes more relevant when considering that Hong Kong with its close proximity and

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[167] Cox Report, Chapter 3, 100.

[168] Ibid., Chapter 3, 121.

[169] Ibid., Chapter 3, 100.

[170] Ibid., Chapter 3, 109.

[171] Ibid., Chapter 3, 127, 128.

[172] GAO, *Export Controls, Information on the Decision to Revise High Performance Computer Controls*, GAO/NSIAD 98-196, Washington, D.C., 1998, 30.

special trade status has a higher tier level than that of China.[173] The probability of uncontrolled diffusion increases under these circumstances. This shows that there is a need to develop technology controls that are designed into innovations to ensure they are used only for intended purposes.

It is important to frame this argument in context of the implications stemming from U.S. MNCs in China as well. International production and research centers that foster innovation and diffusion are relevant to this study's analysis. U.S. companies, such as Intel, IBM, and Advanced Micro Devices (AMD), are all international collaborators in China. Intel and AMD have teamed up with China's Department of Education to design one of the world's most powerful computing grids.[174] This is an innovated cluster-computing network that performs at supercomputer speeds. With collaborative business dealings, China has been able to develop indigenous high performance computer systems of its own. IBM selling production of its "Think Pad" to Chinese computer maker Lenovo evidences this.[175] Moreover, China's Academy of Sciences (CAS), who partly owns Lenova, has collaborated with them to produce a 256-node cluster system using new Itanium 2 processors.[176] Should this close collaboration go on unchecked? Additionally in 2003, AMD and Chinese server developer Dawning co-developed the Dawning 4000A operating at 10 teraflops. This makes the 4000A the world's third most powerful computing system.[177] It is imperative that there is a dynamic technology control structure that examines the risks associated with certain collaborative efforts and ensures technology controls are effective to either constrain the configuration or ensure these powerful computing clusters are used only for intended purposes.

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[173] CRS*, Hong Kong-U.S. Economic Relations*, RS20786, Washington, D.C., 2005, 4.

[174] CNET news.com, China to build national computing grid, 2003, http://news.com.com/China+to+build+national+computing+grid/2100-1010_3-5082097.html (accessed September 5, 2006).

[175] IBM Technology, Lenova chief says it's still the same IBM thinkpad, http://www.ibmtechnology.com/modules/news/article.php?storyid=170 (accessed October 2007).

[176] Grid Today, Intel Powers Network Center of Chinese State Grid http://www.gridtoday.com/03/0728/101731.html (accessed October 2007).

[177] CNET News.com, China, AMD team on Opteron supercomputer, http://news.com.com/2100-1006_3-5055317.html (accessed August 2007).

IBM, with a long collaborative history with Chinese companies, teamed up with the Beijing Meteorological Bureau in 2007 to develop another 10-teraflop cluster computing system.[178] To support the explosive growth of China's IT industry and collaborative research, Sun Microsystems collaborating with China Standard Software Company, will co-develop China's new Java desktop system to support this endeavor. This software will help support collaborative networks that tie together major university as well as government research facilities in China and the world.[179] Intel, celebrating 20 years of collaboration with China, has invested heavily in Chinese growth toward becoming a "knowledge nation" through collaborative efforts with the Ministry of Education.[180] Software is a key element to actually implementing HPC innovations toward an effective end, so controlling certain software applications and programming should be an integral part of any export control plan.

These HPC innovations in China are the direct result of the process with U.S. commercial technology firms. The global enterprise allows computing performance to circumvent U.S. export controls by way of the innovative process. China now possesses computer systems with enough power to develop technologies equal to any nation. Engineering these computer grids into a collaborative framework gives China a distinct advantage in researching and developing new technologies. Why are these collaborative networks not being pursued in the United States with the same vigor? Perhaps controls of HPC interconnection knowledge, processes, hardware, and software should be implemented. This is relevant since these powerful grid networks can be used effectively to develop military capabilities. More incentive needs to be placed on collaborative networks within the United States and less in China. Again, a need for a strategic technological collaborative policy that addresses controlling the processes and knowledge

[178] CNNMoney.com, Rain or Shine, IBM Supercomputer to Power Official Weather Forecasts for Beijing: China Taps IBM for Meteorological Expertise, (2007) http://money.cnn.com/news/newsfeeds/articles/marketwire/0291367.htm (accessed August 2007).

[179] Sun.com, Sun and China Standard Software Company partner to establish the Java desktop system as the foundation for China's fast growing IT industry (2003), http://sun.com/smi/press/sunflash/2003-11/sunflash.20031117.3.xml (accessed August 2007).

[180] Intel.com, Intel Celebrates 20 years In China: New Investments Reinforce Commitment to Chinese Innovation and Education (2005) http://www.intel.com/pressroom/archive/release/20050613corp_a.htm (accessed August 2007).

used to set up complex networks in China. At the same time, this policy should provide incentive for the same type of collaborative investment within the United States while maintaining U.S. commercial competitiveness.

C. CONCLUSION

Antiquated export controls will be ineffective in controlling sensitive satellite and HPC technologies without a strategic and dynamic technology control mechanism. This structure should employ controls that cover processes, knowledge, and software rather than mere export of end units. Additionally, these technologies are available globally, so the Wassenaar agreement should be strengthened to incorporate technology controls of HPC and satellite technology. This agreement should go beyond just looking at the end product (hardware) exports and should focus on collaboratively controlling processes, and knowledge.

One very important step in fixing the current export control situation is effectively determining technology export risk. This requires a completely new approach in controlling technology. Tasking a static agency, such as State and Commerce Departments to stay cognizant of rapidly evolving satellite technology and accurately assess the risk in the export of this technology is ineffective. This system makes export control an afterthought and needs reforming. Export controls need to be designed into technology just as quality controls are designed in. Export controls then become strategic and part of the overall R&D environment that keeps up with the rapidly evolving technology, and can accurately assess the export risk as it innovates. Moreover, a collaborative approach to export controls ensures a common understanding regarding technological exports to China thus reducing miscommunications and mistakes.[181]

The weaknesses discussed in the current export control system shows that it is inadequate to ensure U.S. technological superiority and security. This policy is effective only if the United States maintains its lead in the technological innovative race. Ironically, if the United States fails to maintain the innovative lead then it is plausible that

[181] Freese, 153, 154.

China could control the export of certain technologies exported to the United States. A policy that relies on export controls, no matter the type, is not enough to ensure U.S. economic and security superiority with China.

The satellite study reveals that China is collaborating with the European Space Agency to develop sophisticated satellite technologies. Moreover, the satellite case study showed it is unwise to assume the technological lead enjoyed by the United States will continue without vigilant market analysis and national planning. Early market indicators such as demand and prospective rivals need to be addressed and solutions found early so if policy adjustments need to be made, it can be done in a timely manner to head off a possible competitor. Additionally, China has tested a ballistic missile capable of hitting the mainland of the United States. With this information, it is conclusive that China's intention to use these technologies should be a relevant factor in determining U.S. export control effectiveness. The U.S. has not adequately mitigated China's use of technology for military purposes through its current export-control system.

The HPC study shows that the hierarchical country scheme that mandates controls for high performance computers do not function well without an international control regime. With the higher end technology being distributed throughout most of the world, it is probable that re-exportation to a higher risk country will occur. Moreover, HPC industries such as Intel, IBM and AMD are already heavily invested and collaborating in China. It becomes clear that it is necessary for additional measures to be taken that go beyond just multilateral export controls to ensure against sensitive dual-use technology transfers to China.

IBM, Intel, Sun-Microsystems, and AMD collaborating with China have circumvented controls by innovating high performance computing in supercomputer grid configurations. The inherent problem with this unchecked collaboration is that there is no dynamic risk-analysis mechanism to determine if China will diffuse this technology for military use. The fact is that China has already acquired computer systems, sophisticated missiles, and satellite technologies that can match the capability of most countries in the world. China's technological advancement will continue to increase without an effective U.S. technology control system in place. With so many high tech

firms operating in China, innovation and diffusion make the current export controls to China counterproductive to keeping U.S. high technology innovations centered in the United States. These global companies have moved offshore to collaborate, and innovate with Chinese companies to avoid the ineffective and restrictive U.S. trade policies. They take advantage of China's comparative advantages in labor, operating costs, and growing domestic market. The United States government needs to develop a collaborative strategic technology policy that effectively incorporates export controls into the R&D process so that it strengthens U.S. innovative entrepreneurialism (increased intellectual property rights), and raises technology security.[182]

A dynamic risk analysis process and designed-in technology controls must be integrated early in the R&D process so that the end product can only be used as originally intended, that being benign innovative uses. By developing innovations that effectively controls technology-transfer is key. This designed-in process, using black box technology or encrypted software, would only allow a specific connection arrangement or software function for innovations such as the grid-computing configuration. Any attempt to tamper with these configurations or reverse engineer it would result in the sensitive technology areas self-destructing. Building these grids with this new type of technology controls allows technology transfer control while maintaining innovations to solve problems, and adds collaborative utility between the United States and China. It also strengthens U.S. – China economic interdependence while preserving sensitive U.S. innovations. Ultimately, U.S. commercial competitiveness and national security is of vital importance and so the need for this type of new technology control is warranted.

[182] James A. Lewis, Elements of Innovation, Center for Strategic and International Studies (2005) http://www.csis.org/media/csis/pubs/0805_elements_of_innovation.pdf (accessed January 2008).

III. CONSTRUCTING COLLABORATIVE U.S.–CHINA TRADE RELATIONS

The United States government should focus on incentives to encourage a strong collaborative research and development environment centered within the United States. With the collaborative hub centered in the United States, there is a better chance of controlling the direction of innovation of technologies rather than if China or another global competitor innovates autonomously. The U.S. military benefit of being the commercial innovative leader is a critical objective as well. This approach would require a more competitive approach that takes a less provocative path then reactionary export-control implementation.[183] The United States should instead design in export controls to reduce provocation while strengthening its innovative and economic position.

Chinese technology production intention is a wildcard, which requires a new approach to mitigate less-benign technological innovations when export controls are ineffective due to globalization and diffusion. Globalization has created international research, development, and production that make diffusive controls less effective and competitively counter productive. The goal in globalization is to stay in control of key technologies in the global market. The way to do this and meet policy objectives with China is to stay engaged and maintain innovative leadership and market dominance. In order to accomplish this, much less attention on restrictive and ineffective controls and more attention to maintaining innovative leadership with China are required. The deeper the dependence on U.S. innovations, the more potential influence and control the United States has over China's developmental directions.

No matter where dual-use technology falls on the benign or less benign spectrum, it is difficult to control. The policy choice for the United States should be one that promotes the United States leadership in innovative technologies spanning the entire dual-use spectrum from benign to less benign innovations. Economic incentives used to ensure technological innovation stay centered in the United States should be the top

[183] Arquilla, 366.

priority. “The United States must embrace emerging technologies and rapidly transform its current technological lead, if preserved, would increase our military strength while cutting costs…and reducing the risk to troops.”[184] Given the current level of U.S. technological collaboration with China, emphasizing U.S. collaborative leadership will ensure the United States remain the primary driver of technology markets and standards. This policy choice must be supplemented with a new export control system to achieve and maintain the lead in current and future technological innovations.

Globalization and diffusion of technological innovation has allowed China to continue to gain technologically on the recognized power of the United States. Today, China’s science and technology programs have overcome Japan and will soon bypass Europe in research and development spending.[185] China has implemented this modernization program to coincide with a diplomatic, economic, political engagement of greater Asia. It has been argued that China is embracing and managing globalization, and associated economic interdependence, as a means to restrain U.S. unilateralist policies and promote a multi-polar international system of states.[186] Understanding a realistic view or worst-case scenarios helps to understand and formulate preventative policy options that lend to a greatest outcome utility. Regional fear seems to be rising along with a rising China, so confronting and mitigating this fear is a priority as it lends itself to a spiraling security dilemma and possible regional arms race. The collaborative-engagement policy with China must work to improve U.S. regional soft power as well as lowering the possibility of a regional security dilemma.

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[184] Leslie C. Eliason and Emily O. Goldman, “Theoretical and Comparative Perspective on Innovation and Diffusion,” In *The Diffusion of Military Technology and Ideas*, ed. Emily O. Goldman and Leslie C. Eliason (Stanford, CA, Stanford University Press, 2003), 1.

[185] Organization for Co-operation and Economic Development, *China will become world’s second highest investor in R&D by end of 2006, finds OECD*, http://www.oecd.org/document/26/0,2340,en_2649_201185_37770522_1_1_1_1,00.htm (accessed December 2006).

[186] Yong Deng and Thomas G. Moore, “China Views Globalization toward a New Great-Power Politics?” *The Washington Quarterly* 27:3 (2004): 118-126.

A. COMPREHENSIVE TRADE RELATIONS WITH CHINA

With these regional dynamics in play, it is obvious the status-quo policy of engagement with ineffective export controls does not provide the economic or security leverage to be effective. It is imperative to develop a comprehensive [187] trade relation policy with China centered on technological innovation. The reason technological innovation is essential is that this is the United States' traditional stronghold and because it is the driving factor of globalization.[188] Therefore, maintaining control of this innovative engine of globalization through collaborative leadership supplemented with effective export controls is an economic and national security priority for the United States. This collaborative-engagement policy should incorporate other regional powers such as Japan and South Korea to form a U.S. collaborative sphere of influence.

An important lesson learned from the HPC and satellite case studies is the realization that export controls alone will not meet U.S. objectives for mitigating China's technological rise and prevent a possible security dilemma in East Asia. If the United States does not adequately access the risk of new technology transfers to China and put in technology controls to prevent it from diffusing into China's military, it could lead to an unintended arms race, and spiral into a full-blown war over sensitive issues such as Taiwan's independence. The irony here would be that China would use U.S. technological innovations militarily to battle the United States.

Conversely, the current bureaucratic export controls will not keep the United States, in a global market construct, technologically competitive and able to produce and control its future military technology requirements. Taking a dichotomous view of export controls without acknowledging and factoring the strategic or long-term economic effects of globalization is counter-productive as shown in the satellite study. Export controls should be dynamically inserted into the R&D phases. In other cases, it is

[187] Peter J. Katzenstein and Nobuo Okawara, "Japan, Asian-Pacific Security, and the Case for Analytical Eclecticism," *International Security* 26:3 (2001/02): 154.

[188] Peter J. Hugill, "Technology, its Innovation and Diffusion as the Motor of Capitalism," *Comparative Technology Transfer and Society* 1:1 (2003): 89-100.

impossible to control benign technology in a global market construct, due to its inherent innovative diffusive and so controlling processes and knowledge is essential as shown in the HPC study.

China, as a beneficiary of globalization, has become or is becoming a leader in technological research and development. China's Gross Domestic Product (GDP) is rising faster than every country on the planet.[189] By taking advantage of the growing global market and continued innovative diffusion, China is able to acquire or produce advanced technology to allow it to compete with the United States commercially and militarily. This diffusion and increased capital has translated into an increasingly modernized military as well, far surpassing expectations.[190] Facing these facts must be a priority factored into developing a trade policy with China. It must confront these specifics and result in a way of dealing with China's rise, as well as satisfying U.S. regional and domestic interests. Additionally, achieving this will be commensurate with promoting U.S. technological competitiveness. Instead of trying to control technological diffusion, a need exists to construct technological innovation toward common positive utilitarian goals.

Thus, given all the East Asian variables, there is a requirement for a more dynamic trade policy approach that focuses on U.S. technological collaborative and innovative leadership necessary to meet U.S. objectives. This action is termed Strategic Technological Collaborative Leadership (STCL), and would be supplemented with a superior technology control mechanism that would not interfere with trade to China. It would however prevent its use in military applications. This approach is far superior in meeting U.S. economic and security long-term interest than the mere use of engagement with tactical technological export controls.

[189] Wayne M. Morrison, *China's Economic Condition*, (CRS IB98014, 2006): 1.

[190] John J. Tkacik Jr., "Panda Hedging: Pentagon Report Urges New Strategy for China," *The Heritage Foundation* No. 1093 (2006):1. A pretty hawkish source who is always surprised by the new capabilities of the Chinese.

B. POLICY OPTIONS

1. Conservative Policy Option

It is in the realist vein that security concerns with China's hard power intentions call for a conservative regional foreign policy closer to containment with a restrictive technological trade policy. Many scholars and policy advisors have serious concerns regarding China's rise and ambitions in East Asia and the implications for the United States.[191] A powerful China could be able to hinder or even block the United States if it felt it is necessary to send forces to Asia to protect its interests there. For this reason, some scholars believe in both stricter trade controls with China, along with stricter control regimes that will limit or eliminate re-exportation to China from friendly countries that do not share the same security concerns about China, as does the United States.[192] Another group argues about the precarious position the United States military industrial complex may find itself in if it becomes dependent upon technology owned by or imported from China.[193] Still others see a possibility of China proliferating militarized western technology to rogue or enemy states such as Iran or North Korea.[194]

[191] John J. Mearsheimer, *The Tragedy of Great Power Politics* (W.W. Norton: New York, N.Y., 2001): 397-402; David Shambaugh, "China Engages Asia: Reshaping the Regional Order," *International Security* (2004/2005): 99; Department Of Defense, *Quadrennial Defense Review Report* (DOD: Washington, D.C. 2006): 28-30.

[192] Richard Bernstein and Ross H. Munro, *The Coming Conflict with China.* (New York: Vintage Books, 1997): 217; Bill Gill and Taeho Kim, *China's Arms Acquisition from Abroad.* (New York: Oxford University Press, 1995); Richard Fisher, "How America's Friends Are Building China's Military Power," *Heritage Foundation Backgrounder* no. 1146 (1997); David Makovsky, "U.S. Worried About Sale of Israeli Technology to China," *Jerusalem Post* (1996): 2; Tony Capaccio, "U.S., Israel Using 'Low Key' Process to Air Arms Retransfer concerns," *Defense Week* (1995): 6.

[193] Duncan Clarke, Daniel B. O'Connor, and Jason D. Ellis, *Send Guns and Money: Security Assistance and the U.S. Foreign Policy* (Westport, Conn.: Praeger 1997): 175-78; John Wong, "China's Outward Direct Investment: Expanding Worldwide," *China: An International Journal* 4: 2 (2003): 273-301; Uli Schmeter, "*What's the Motorola Chip Doing in Land Mine?*" Chicago Tribune (1994); Kenneth R. Timmerman, "*Close-Out Sale at Commerce*," American Spectator (1995), 40; Robert Johnston, "U.S. Export Control Policy in High Performance Computer Sector," *Nonproliferation Review* 5 (1998): 52-54; Barbara Opall-Rome, "China Leads Supercomputer Charge," *Defense News* (1999): 8; Government Accountability Office, *China: Military Imports from the United States and the European Union since the 1998 Embargoes.* (GAO NSIAD-98-176: Washington, D.C. June 1998): 2-4; Paul Blustein, "China Plays Rough: 'Invest and Transfer Technology, or No Market Access'," Washington Post, October 25, 1997, C1.

[194] Bill Gertz, "China Aided Iran Chemical Arms," *Washington Times*, October 30, 1997, A1 and Chaim, Braun C., "Proliferation Rings: New Challenges to the Nuclear Nonproliferation Regime," *International Security* 29:2 (2004), 5-49.

These examples describe the security concerns associated with liberal trade that does not adequately emphasize export controls and recognize China's regional threat. Exporting dual-use technology, outsourcing research and development (R&D), and off shoring of U.S. companies to China only exacerbates the security implications China's advancement brings. These concerns combine and cause many conservatives to call for increased export controls and regimes.

While conservative arguments cover short-term security aspects, they do not adequately address a balancing of U.S. security needs with U.S. commercial competitiveness. Additionally, it neither addresses the importance of maintaining U.S. strategic technological innovation nor collaborative leadership in global trade. There is a need to address the problems associated with the ability to control technological innovative diffusion within the global trade construct. Addressing these problems has become increasingly important, as the U.S. military has become increasingly reliant upon U.S. commercial competitiveness to meet its own technological requirements.[195]

2. Liberal Policy Option

Perhaps domestic politics and economic interdependence raise the cost or risk factors of overt power politics and power balancing. Liberal arguments such as these find support among such theories as the Democratic Peace Theory and the Kantian Peace Triangle.[196] Unlike realism, liberalism brings the actor from the state to the domestic arena.

> The fundamental actors in international politics are individuals and private groups, who are on average rational and risk-adverse and who organize exchange and collective action to promote differential interests under constraints imposed by material scarcity, conflicting values, and variations

[195] Jane's Information Group, "The Evolution of COTS in the Defense Industry," Jane's Defense Industry (2000) http://www8.janes.com/Search/documentView.do?docId=/content1/janesdata/mags/jdin/history/jdin2000/jd75e5~0.htm@current&pageSelected=allJanes&keyword=COTS&backPath=http://search.janes.com/Search&Prod_Name=JDIN& (accessed September 2006).

[196] John R. Oneal and James L. Ray, "New Tests of Democratic Peace: Controlling For Economic Interdependence: 1950-1985," *Political Research Quarterly* 50 (1997): 751-75; Bruce Russett and John Oneal, *Triangulating Peace: Democracy, Interdependence, and International Organizations* (New York: W.W. Norton 2001).

> in societal influence…Socially differentiated individuals define their material and ideational interests independently of politics and then advance those interests through political exchange and collective action. Individuals and groups are assumed to act rationally in pursuit of material and ideal welfare.[197]

The question for the liberal approach is how to define this ideal welfare? A need to focus groups, individuals, and indeed states on this ideal seems also necessary for the utility of this approach to work. The pursuit of material welfare and asymmetric economic interdependence did not allow Europe to escape the First World War when economic interdependency in Europe was very high.[198] Perhaps it is how political leaders perceive future trade (pessimistic or optimistic) that determines whether they will go to war or not. With high interdependence, but a pessimistic view of future trade prospects, war can still break out.[199] This idea connects the collective idea of how speculative future trade prospects are. With globalization and economic interdependence levels today, this would point out the dire consequences of a global economic downturn. The institutional checks and balances brought about through the liberal international institutional dynamics do provide better cooperation, due to less uncertainty, than under strict anarchy but only to a limit.[200]

Liberal US-China trade policy prescribes a foreign policy of engagement with China. There are liberal arguments that point to China's improved export control or the value of economic benefits attributed to a liberal U.S.-China trade policy. The argument in favor of a more liberal trade policy with China are contingent upon China's adoption of improved export control regulations that cover missile technology, chemical weapons precursors and technology, and biological agent related items. This policy shift can be

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197 Andrew Moravcsik, "Taking Preferences Seriously: A Liberal Theory of International Politics," *International Organization* 51:4 (1997): 516.

198 Copeland.

199 Ibid., 7.

200 Ted Hopf, "The Promise of Constructivism in International Relations Theory," *International Security* 23:1 (1998): 190.

attributed to China's increased recognition of the dangers that proliferation of these sorts of weapons and weapons systems pose to its own security and to an effort to improve relations with the United States.[201]

The other large faction of scholars argues that keeping the U.S. trade policy liberal will discourage conflict between the United States and China. As interdependent trade increases between countries, the cost of conflict rises between the two trading partners. These arguments are against protectionist policies, such as export controls, which might dominate future U.S.-China relations. Most of these scholars down play security concerns and point to positive aspects of China's rise, through its multilateral or bilateral engagement, good-neighbor policy, or just being incapable or unwilling to balance against the United States. They argue against viewing China as a threat and for the U.S. Congress to cooperate with China in mutually beneficial ways. It is in China's interest to deepen and extend economic reform by opening its capital markets.[202] Still others argue that globalization and engagement help maintain the United States' lead in Science and Technology (S&T) knowledge dominance that is essential in maintaining military dominance against potential foes such as China.[203]

The problem with these arguments of the more liberal policies is that they do not deal adequately with the security concerns of less benign technologies militarized by China and the threat China still poses to the region, specifically to Taiwan. Additionally, even though they are economically oriented, these arguments fail to address sustained U.S. technological competitiveness in a global construct where China is becoming a

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[201] Stephanie Lieggi, China's White Paper on Nonproliferation: Export Controls Hit the Big Time, Nuclear Threat Initiative (NTI) (2003) http://www.nti.org/e_research/e3_36a.html (accessed December 2006); Government Accountability Office, *Foreign Trade Law in China and its Revision* (GAO: Washington, D.C. 2005): 50-73.

[202] Katherine Barbieri and Gerald Schneider, "Globalization and Peace: Assessing New Directions in the Study of Trade and Conflict," Journal of Peace Research 36 (1999): 387-404; James Dorn, "China's future: Constructive Partner or Emerging Threat," *CATO Institute* (2000): 5; Robert L. Paarlberg, "Knowledge as Power: Science, Military Dominance, and U.S. Security," *International Security* 29:1 (Summer 2004): 122–151; Avery Goldstein, "Great Expectations: Interpreting China's Arrival," *International Security* 22: 3 (Winter 1997/98): 43; Andrew J. Nathan and Robert S. Ross. *Great Wall, Empty Fortress: China's Search for Security*. (New York: W.W. Norton, 1997); Hugill, 89-100; Michael G. Gallagher, "China's Illusory Threat to the South China Sea," *International Security* 19: 1 (1994): 169-194.

[203] Robert L. Paarlberg, "Knowledge as Power: Science, Military Dominance, and U.S. Security," *International Security*, 29:1 (Summer 2004): 122–151.

strident competitor. As with the conservative policies, they do not address China's unchecked soft power nor do they adequately address a plausible way of steering (controlling) regional technology innovation in a positive if not benign direction.

3. Social Constructivist Policy Approach

There is much at stake in this complexly interdependent world. The culture of fear created by the primal anarchic international system of states and the still petulant culture of risk versus reward trade-offs needs constructing toward a culture of collaboration and trust. This goal oriented culture works to influence positive social change, helping to steer the regional dynamics in a positive direction. A need exists for a policy that fosters newly constituted norms, knowledge, practices, and state identities through the social constructivist notion of "providing meaningful behavior or action within an intersubjective social context."[204] The conservative and liberal approaches fail to put in place the mechanism of positive change. With the conservative and liberal approach, the system drives the problem leaving realism or liberalism to chance. The Social Constructivist approach puts society in control of its own destiny and has the greatest utility for positive change. The United States maintaining the leadership position in a collaborative sphere of influence will allow such a social dynamic that fosters this level of change.

Constructivism argues, "Actors develop their relations with, and understanding of, others through the media of norms and practices…. 'Constitutive norms and define an identity by specifying the actions that will cause others to recognize that identity and respond to it.'"[205] An identity could be a great power state, rising state, rogue state, even the anarchic structural system of states. If this is the case, than it can be argued that without constitutive norms and practices, these "identities" are without definition and are void of meaning.[206] These identities socially constructed through constitutive norms and

[204] Hopf, 173; Intersubjective social context can be thought of as the contextual socialization that occurs within a social group.

[205] Ibid.

[206] Ibid.

practices that work through the international system of anarchy are what states make it.[207] There also can be different meanings of anarchy among states due to different communities of intersubjective understandings and practices. Anarchy then would become an "intersubjective anarchic structure." The intersubjective structure determines the meaning of identities by others.[208]

4. The Foundation of a Collaborative-Engagement Policy with China

One key utility for building U.S. – China relations is through Strategic Technological Collaborative Leadership (STCL). The goal of the U.S. STCL is to stay ahead in existing and new pioneering technologies by using strategic collaborative networks both domestically and internationally. These networks or spheres result in allow the United States to use STCL to ensure its collaborative partners all share the same understanding of the risks associated with sensitive technology transfers to China. Additionally, it focuses R&D to pursue ways of designing in new technology controls that ensures technology is only used as intended. Additionally, by taking a leadership position, the United States retains critical collaborative knowledge essential for innovating new technologies. Due to shared interest, knowledge, and social pressure to solve environmental and energy demands, the United States can use a national technology incentive arranged in a collaborative arrangement to make positive change in the East Asian region now and in the future. Moreover, this will also allow for new spin-on military innovations that ensures continued U.S. military prowess. Leading in the innovative process to solve these important issues will require the efforts of many states, departments, and agencies that require a collaborative policy approach to meet common objectives. The United States taking the lead in this process is the essence of the Strategic Technological Collaborative Leadership (STCL).

> The requirement for collective action to achieve common purpose or attack common problems is a natural consequence of the increasing integration of economies and societies. That requirement is bound to grow

[207] Alexander Wendt, "Anarchy Is What States Make It: The Social Construction of Power Politics," *International Organization*, 46:2 (1992): 391-425.

[208] Hopf, 174.

> as integration increases and becomes an ever more prominent aspect of international transactions among nations. Much of the existing international cooperation takes place in the private sector, without extensive government involvement; a large and growing portion of it requires the commitment and agreement of governments on subjects of substantial political and economic significance.[209]

Technological collaboration not only increases innovative capacity but also with proper leadership draws regional players to shape technological innovations to meet regional socio-economic interests. Collaboration among states will increase as the need to solve global issues becomes more politically salient.[210] The objective is framing these interests within a common utilitarian understanding created through social constructivist principles. The social interaction provided by the collaborative action brings about all of the constructivist promises. STCL enables the "collaborative-engagement" policy to be a successful strategic U.S. economic, and security tool. STCL is, therefore, a vital component of the collaborative engagement with China. Without such a tool, engagement is hollow or without means to an end. This tool gives the policy action to execute the greater ideals and utility proposed in the policy. With proper U.S. leadership, it provides a means of enabling the dynamics of social constructivism and soft power to work to the advantage of the United States' liberal ideals.

This environmental crisis left unchecked could negatively affect China's economic expansion and political stability. This would have a negative effect on the global economy, which directly affects U.S. economic and security interests. Perhaps changing the anarchic intersubjective structure from an egoist form of "self-help" to a more utilitarian form would help prolong the global economic structure and ensure China's, as well as the worlds', political and economic survival. State survival provides the impetus for state behavior in the self-help intersubjective structure, so too in the utilitarian collaborative structure.

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[209] Eugene B. Skolnikoff. The Elusive Transformation: Science and Technology, and the Evolution of International Politics. Princeton University Press, Princeton, New Jersey, 1993, 210.

[210] Ibid., 211.

One instrument the United States could use to create a more utilitarian collaborative structure is through leadership in technological innovation. Technological innovation could hold the promise of solving many of China's, and the entire East Asian environmental and energy issues now and in the future. This collaborative structure would only work to U.S. advantage by incorporating a dynamic technology control mechanism to protect and keep key innovative technologies centered in and controlled by the United States. The collaborative engagement of East Asia would also ensure U.S. regional positive influence remains strong. Conversely, technological advancement is not always progressive as evidenced by the weaponization of dual-use technologies. The view of most scholars is that technology is neutral and needs shaping into either a benign or a less benign technology.[211] In order to control or shape overall progression of technology innovation, it is useful to think of technology as a form of knowledge and knowledge as power.[212] Knowledge is so vital it must be protected and incorporated into the export control apparatus. The United States could build this power by maintaining its leadership position in helping solve China's long standing environmental and energy difficulties while protecting these vital technology innovations. Moreover, the lead in this technology would allow the United States to maintain control over technology standards, and thus, the global market in key future technology sectors. This part of the collaborative-engagement foreign policy should be coupled with the dynamic technology export control mechanism to ensure both economic and security requirements are met.

Social Construction of Technology (SCT) is the ability of social interests to shape future technologies.[213] If shaped toward utilitarian goals or interests, it would provide the means of replacing the "self-help" materialist intersubjective structure with a more utilitarian structure. The intersubjective interests evidenced in China's social demands over environmental issues and energy needs makes social shaping of technology feasible

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211 Brian Martin, "Social Defense Strategy: The Role of Technology," *Journal of Peace Research* 36:5 (1999): 537.

212 Ann Johnson, "Revisiting Technology as Knowledge," *Perspective in Science* 13:4 (2005): 554, 555; Robert L. Paarlberg, "Knowledge as Power: Science, Military Dominance, and U.S. Security," International Security 29:1 (Summer 2004): 137.

213 Johnson, 539.

and likely to influence government policy toward more benign technology advancements, which will meet these social demands and spur economic growth. This common social interest is feasible enough to be politically, socially, and economically feasible in the greater East Asia region where Malthusian issues will only get greater in the coming years.[214]

SCT provides a way of shaping new technology to promote goal oriented ideas and roles that steer technological innovations and regional social dynamics in a positive direction. A U.S. led social construction of technology would then provide the means of making the utilitarian structure a reality. Melding the social dynamic of SCT into STCL creates the motive force driving the collaborative-engagement policy with China. One major goal of this collaborative policy would be to create a power balance in East Asia based on knowledge and science. This knowledge power has a socially transforming effect that can translate into greater social, economic, political interaction and utility.[215] This dynamic as previously stated lowers uncertainty, security dilemmas, and negative economic and environmental factors. This type of competition is not pessimistic but socially constructed for the betterment of humankind and long-term survival. U.S. collaborative-engagement would mitigate the realist regional tendencies and increase the global economic side of the liberal argument as trade and profit would increase. It would spur new technological competitiveness and provide the United States with continued access to new technological innovations that directly benefit military industrial concerns.

The United States leads in technological research and development and innovative capability; therefore, it should lead in this collaborative role. This leadership would ensure U.S. economic gains, technological standards and competitiveness, and as a design function, could shape technological innovations to a benign utilitarian nature demanded by society.[216] This would be a much more effective and comprehensive approach then relying on ineffective export controls to limit less benign technological innovations and weaponization of those technologies.

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[214] Skolnikoff, 163.

[215] Johnson, 554-572.

[216] Skolnikoff, 150-174.

5. Implementation of the (Collaborative-Engagement) Policy

This collaborative-engagement policy is both domestic and international. Domestically the policy must be a national strategic technology initiative with Executive Branch support and many collaborative branches. This policy is analogous to a strategically focused Science and Technology (S&T) policy that focuses on technological innovative and collaborative leadership with an incorporated dynamic export control mechanism. The U.S. President must set the urgency for this policy.

> Now is the time to make these changes. Long-standing budgetary constraints preclude the State Department from vigorous action, even if the will to act were there. The initiative must come from elsewhere: the scientific and engineering communities, the White House, and the Congress. Leaders from all these groups recognize that in the post-Cold War era, S&T and foreign policy have more, not fewer, inter-relationships.[217]

The first step would be to abolish the U.S. policy that hampers certain technological collaborative efforts with China. These restrictions include overseas private investment corporations and the U.S. – Asia Environmental Partnership after the Tiananmen Square Protest in 1989.[218] These restrictions hamper the U.S. ability to affect a collaborative-engagement policy with China. This should only be lifted when a new dynamic export control system ensures new innovative technologies vital for U.S. military requirements are met. Additionally, the U.S. government must be ready to subsidize U.S. technological innovations that warrant export controls. This allows an ability to grow indigenous innovations on a level playing field with its global competitors. Innovations under this policy would be somewhat more expensive initially when unable to take immediate advantage of the global market. Federal investment is critical to making this new form of export controls a reality. This effort must be a very high priority for the government and the entire country.

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[217] J. Thomas Ratchford, "Put Science and Technology Back into Foreign Policy," *Science* 282:5394 (1998): 1650.

[218] Elizabeth C. Economy, The River Runs Black: The Environmental Challenge to China's Future, Cornell University Press, Ithaca, NY (2005), 273.

To influence the shaping of China's and the East Asian regions technological development toward a more benign utilitarian course, a regional collaborative triad or quad will need to be constructed. This will require a very diligent multilateral diplomatic effort arising from the U.S. State Department. The State Department through its ambassadorships and trade representatives must start its own collaborative network to formulate and shape the intersubjective interests themselves. This network would foster collaboration to develop new technologies to improve environmental conditions and energy demands. "The environment provides a natural and non-threatening vehicle to advance U.S. interests not only in China's environmental protection efforts but also in its basic human rights practices and trade opportunities."[219] In order to do this, the State Department must recognize how essential technology is to foreign policy, and therefore, delegate the STCL initiative to key science and technology institutions such as DARPA and the Nano Science and Technology Institute for execution and coordination.[220]

Japan and South Korea would be two key players within a multilateral triad with the United States being the other collaborator. These two countries already collaborate with China in a number of environmental areas such as acid rain and marine fishery monitoring and management, and they thus provide an excellent starting point.[221] A diplomatic push for consensus between these two countries first would accomplish two vital objectives. First, it would help foster better relations between these two countries and help to get past years of historical friction and mistrust. Second, it would strengthen U.S. soft power and help to counter-balance China's regional influence. The check of China's rising soft power could mitigate the possibility of China "isolating and defeating," and possibly using force against Taiwan.[222] Additionally, by maintaining a

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219 Economy, 273.

220 Ratchford, 1650.

221 Economy, 204.

222 Chang Yun-ping, Taiwan Security Research, China's Shift Poses New Challenges: Academic, Taipei Times, July 15, 2006 http://www.taiwansecurity.org/TT/2006/TT-150706.htm (accessed October 2007).

U.S. collaborative umbrella, Japan does not have the need to develop nuclear weapons that could complicate the regional situation with a Sino-Japanese nuclear arms race.[223]

South Korea and Japan would have to agree to a new stricter Wassenaar control mechanism that would ensure vital technology innovative knowledge that is collaboratively developed will not be transferred to China. With a stricter Wassenaar agreement, the United States, Japan, and South Korea form a collaborative sphere of influence that can better focus technologies to find solutions to energy and environmental issues. This collaboration, coupled with designed-in technology controls, prevents secret technology innovations from reaching China while promoting new innovative trade throughout the East Asian region. It will also allow the United States to expand technology controls to create an export control regime effectively in East Asia. The United States would of course be the leader of the collaborative East Asian sphere.

The Commerce Department will have to better coordinate collaborative trade activities and better advise all levels of U.S. government of the trade policy adjustments required to remain the strategic collaborative leader. The main emphasis of the Commerce Department's leadership should not only negotiate with Japan and South Korea but also the EU, Canada, and others to form new collaborative spheres that can effectively control dual-use technology. These collaborative spheres should renegotiate the Wassenaar agreement to incorporate new designed-in technology controls. This would enhance economic cooperation with U.S. allies and ensure China is not allowed to diffuse sensitive technology into its military. This network will also ensure a collaborative use of technology between the U.S. – EU that reduces the time lag it takes to get satellite technology to market created by the old bureaucratic export control process.[224] It would also ensure issues such as the loss of the GPS technology due to lack of collaboration, as nearly occurred in the satellite case, is avoided. Conversely, it

[223] Evan S. Medeiros and Jing-dong Yuan, "A U.S. military presence in Asia: offshore balancer or local sheriff?" *Jane's Intelligence Review* (January 2001): 33-35.

[224] James A. Lewis, Regulating Satellite Exports, Center for Strategic and International Studies, http://www.csis.org/media/csis/pubs/030502 regulating satellite exports.pdf (accessed January 2008).

should also work to enhance cooperation and communication with China on trade issues and new multilateral initiatives that bring China closer into new interactions with the West.

In order to keep U.S innovative entrepreneurialism, science and technology education is vital. Without this innovative strength, export controls are a mute point. The Department of Education's role in this policy is vital. Without well-educated citizenry, the United States cannot expect to remain the technological innovative or collaborative leader. There is a need for scientists and engineers that are collaborating internationally to solve the many problems facing states within the GPE. Without a strong export control mechanism, which protects entrepreneurial innovative risk, the United States may face an exodus of innovation. Fully understanding and capitalizing on the benefits of an international collaborative educational system, the United States will be able to maintain its STCL status particularly in East Asia. "The American people should better understand the importance of international S&T, including both the scientific benefits to American researchers and the important spillover effects on U.S. foreign policy."[225] Mathematics, science, and philosophy are key areas to provide understanding to all of the vital technical, economic, and social objectives of this policy. Implementing a collaborative educational effort at the university levels allows a joint learning experience between U.S. and foreign students. This would benefit the collaborative social environment needed to keep this effort moving forward. All of these efforts will help to ensure U.S. technological competitiveness in the global marketplace. A strong national collaborative education initiative would make the Department of Education a more relevant player in the global context. Conversely, restrictive national export controls stifle the collaborative educational opportunity due to the restricted nature of knowledge sharing. Many global universities do not collaboratively engage with U.S. universities due to complicated export controls limiting the exchange of sensitive research knowledge.[226] This puts the United States at a collaborative disadvantage, which undermines future U.S. innovative and collaborative leadership potential. A dynamic export control system that is built into

[225] Ratchford, 1650.

[226] Barry Bergman, Research under fire: In the war on terror, academic freedom could wind up as collateral damage, UC Berkeley News http://www.berkeley.edu/news/berkeleyan/2005/01/27_acfreedom.shtml (accessed October 2007).

the collaborative R&D structure that more effectively communicates what types of information and processes can be used to collaborate abroad is needed. That is the reason this policy calls for a strategic collaborative technology policy to ensure strategic communication that mitigates mistakes is realized.

Saving the most important for last, DARPA is integral to making the entire collaborative-engagement policy a reality. DARPA should be reorganized to focus its R&D into new ways of protecting technologies from being used outside its intended purpose by any country outside the U.S. collaborative sphere. Just as important as designing in quality into technology, so is designing in control. DARPA must focus on new ways of controlling technology like black box technologies that self-destruct when used for other than intended purposes. Another innovation would be to develop new encrypted software technologies that self-destruct if tampered with or used incorrectly.[227] In order for this to be done effectively and efficiently, DARPA must be directly involved with the collaborative research and development of new technologies in the United States.

Most importantly is that DARPA must collaborate with other engineering and science researchers and developers to build in these new types of control technologies. This would be vital because DARPA must be able to determine which technology innovations have military use, assess the risk, and integrate technology controls into the design process. This would keep DARPA at the cutting edge of technology innovations and able to effectively plan and adapt new controls into the innovative process. This would help in controlling dual-use technology areas, such as High Performance Computing, that are rapidly innovating. DARPA would also be able to analyze processes that need to have technologies developed to protect them, such as with cluster computing. All this requires technology controls becoming a integral part of the R&D process. This process would be DARPA's focus. Being involved early in the design process saves money and allows more communication about protecting technology transfers. DARPA must also be the conduit for the U.S. government to invest in this new type of technology

[227] Government Accounting Office, Export Controls: System for Controlling Export of High Performance Computing Is Ineffective, GAO-01-10, 32.

control research. DARPA then can determine which technology needs subsidizing early in the design process and protect these vital controlled technologies until they are fully developed and globally competitive. By developing new black box technology controls or technologies that can only be used as intended, strengthens intellectual property rights in the United States as well. This strengthens entrepreneurial innovation and ensures U.S. technological competitiveness.[228]

The main importance here is that DARPA is a collaborative partner that is now developing new technological innovations that have built-in export controls. This "designed in" approach is the key to limiting sensitive technology transfers to China with limited disruption to commercial trade. For this reason, a doubling of basic and applied research and development is necessary. Frontier technological innovations are found through basic and applied research. It is imperative for DARPA and its research consortium to collaborate with the EPA, NSTI, DOE, DOD MIC, national labs, universities, as well as other countries collaborative structures, on these new technological control developments. This will ensure the United States has long term and efficient spin-on military applications, and continued commercial technology competitiveness. With DARPA designing in technology control, the State and Commerce Department's implementation of export controls as an after thought is eliminated.

C. CONCLUSION

Globalization has allowed China's technological power to rise dramatically. Technological innovative diffusion has already taken place and is expected to continue. It is time for a change in U.S. trade relations; one that focuses less on archaic protectionists' measures and more on dynamic competitive strategies. While dangers and security concerns do exist in the East Asian region, the realist and liberal approach for controlling technological diffusion fails to adequately control technology transfers to China, or meet U.S. security and economic competitiveness needs.

[228] James A. Lewis, 1-4.

A policy which shapes technological innovation while at the same time protects it from transfer to China, is found in the social constructivist' international relations theory which allows change by shaping the intersubjective web of understanding. Specifically, this is done by replacing the self-help intersubjective structure, found within the materialist' concerns, with a more utilitarian structure of collaboration. Of course, this can only be realized if technology innovation is safely centered in and controlled by the United States. To do this, a collaborative-engagement policy with China should be implemented that puts in place a dynamic new technology control approach coupled with U.S. strategic leadership in technological collaboration abroad. This combination ensures technology is used only for intended purposes, and ensures technology stays centered within U.S. control.

The way to combat these issues, while at the same time countering China's soft power rise, increasing regional stability, and prolonging economic growth, is through a policy of collaborative-engagement. Combining the theory of Social Construction of Technology (SCL) with a Strategic Technological Collaborative Leadership (STCL) along with a dynamic technology control mechanism, forms the main instrument of the collaborative-engagement policy. With innovations designed to safeguard sensitive technology, the United States can implement this collaborative-engagement policy to maintain the lead in regional knowledge, technology, and influence. It can use this policy to help socially-shape new technologies into more benign technologies made to maximize utility. By forming a strategic triad of collaboration with Japan, South Korea, EU, and Canada, it can work through regional collaborative spheres of influence to strategize environmental, energy, and security issues within this new intersubjective structure to create a new era of trust, cooperation, and communication.

Making this work will require top down leadership in the United States to make this a national priority with adequate resources. This priority will require huge investments and reforms in many governmental, as well as commercial technological research areas. This reform would be one that implements a structure of collaboration among all research and education areas. Of course, a huge investment in basic education that focuses on collaborative learning is essential. Thus, given all of the East Asian

variables, there is a requirement for a more dynamic trade policy approach that focuses on U.S. technological collaborative and innovative leadership necessary to meet U.S. objectives. This collaborative-engagement policy is far superior in meeting U.S. long term economic and security interest than the mere use of engagement with tactical export controls that are a mere after thought.

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IV. ENTER NANOTECHNOLOGY

The significance of this thesis culminates in the discussion of Nanotechnology, which has the potential of bringing a true broad-based technology revolution. This technology is likely to produce many innovations with moral, ethical, and security implications stemming from the variety of innovation possibilities.[229] This new technology equates or exceeds the importance of the development of the computer or even the nuclear bomb. The world stands at the precipice to determine who will control this upcoming technology.

Nanotechnology is the ability to produce and manipulate matter at the molecular scale. This technology and its innovative applications has revolutionary applications in the IT area such as extremely small, efficient, and cost effective computational devices, sensors, and switches. Nanotechnology also holds promising advances in biomedical field but does portend some rather negative military implications. Nanotechnology could economize current satellite cost while introducing new missions such as tactical space support and logistics.[230] Additionally, this technology has an even darker side; "In addition, advances could empower the proliferation of currently controlled processing capabilities (e.g. nuclear isotope separation) with associated threats to national security."[231] Unlike satellite and HPC technology, nanotechnology is still in its infancy where research and development will be critical to determine who will become the leader in this field. Nanotechnology straddles between HPC and satellite technology in terms of the benign technology level with many implications still to be determined.

With nanotechnology offering the possibility of a true technology revolution, the battle for the global market has begun through research and development of this coming technology. China has shown remarkable progress in this technology because it offers the

[229] Adam Keiper, "The Nanotechnology Revolution," *The New Atlantis, Number* 2, (Summer 2003): 17-34.

[230] Philip S. Anton, Richard Silberglitt, and James Schneider, "The Global Technology Revolution: Bio/Nano/Material trend and their synergies with Information Technology by 2015," *National Defense Research Institute RAND (*2001), 30.

[231] Ibid.

goal of the 863 plan and a shot at controlling the global market through the technological innovation it provides. Since the year 2000, China's world share of core international scientific journal articles related to nanotechnology is second only to the United States.[232] Journal articles are a well-respected indicator of research output. What is more remarkable is the noted sustainable exponential growth of nanotechnology articles and citations, which is unique to all countries conducting this type of research.[233] Conversely, the United States, although possessing a greater world share of journal articles related to nanotechnology, has recently had a flat or slightly decreasing output rate.[234] "These results indicate of China's excess capacities to launch more research in nanotechnology, since expertise and manpower are available in nano-relevant sciences."[235]

With the importance of maintaining the lead in nanotechnology research evident, it is vital to use this technology within the collaborative framework. Being an inherently interdisciplinary endeavor, global collaboration in nanotechnology is crucial for the United States to maintain the lead in technological innovations nanotechnology promises. China has no barriers preventing collaboration with the development of nanotechnology whereas the United States may if it continues its antiquated protectionist controls against such collaboration due to fears of sharing knowledge. However, there are areas that the United States has collaborated with the world. The U.S. EPA and Energy Departments have pioneered research into the environmental and energy implications of nanotechnology. This research has brought about numerous breakthroughs using nanotechnology in the areas of pollution clean up, detection, removal, and prevention.[236] "Nano-sized cerium oxide has been developed to decrease diesel emissions, and iron nanoparticles can improve detection and tracking of contaminants."[237] It has also brought

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[232] Ping Zhou and Loet Leydesdorff, "The Emergence of China as a Leading Nation of Science," *Research Policy* (forthcoming): 30.

[233] Ibid.

[234] Ibid., 21.

[235] Ibid., 22.

[236] U.S. Environmental Protection Agency, "Nanotechnology White Paper," *Science Policy Council U.S. Environmental Protection Agency*, External Review Draft (2005): 9.

[237] Ibid.

to light revolutionary energy production solution that can meet East Asia's growing energy demands.[238] Nanotechnology is a multidisciplinary technology requiring collaboration within the fields of nanotechnology, biotechnology, information technology, and cognitive technology. The unique nano-innovations developed by the collaborative nature of these fields create new challenges in achieving effective environmental regulations and standards.[239] "As these technologies progress and as novel products emerge, increasingly, the EPA will find that meeting constantly changing demands will require proactive actions and planning."[240] With the EPA leading the way in developing this revolutionary technology toward environmental protection, it is imperative that this agency be a collaborator. Collaborative-engagement with Japan, South Korea, EU, and Canada forming spheres of influence to control less benign innovations from transferring to China is the goal. It is also imperative that the EPA collaborate with DARPA and all the universities and research labs within the United States and worldwide. DARPA will have to design in technology controls into this rapidly innovative technology. With this technology inherently collaborative, having a collaborative structure in place both domestically and internationally is essential to remain the nanotechnology innovative leader. Additionally, this structure promotes IPR that motivates entrepreneurial innovators to invest, and keep the technology based in the United States. With this all in place, the United States military will be assured access to nanotechnology spin-on innovations to use directly in military application.

A. CONCLUSION

Globalization, innovation, and diffusion of technology have worked well to allow China to skip existing technologies to focus on new innovative ones. This leapfrog approach has allowed China, through technology transfer and sustained domestic and foreign investments, to focus on new technologies without having to worry about cumbersome military industrial infrastructure costs. China can focus on a technical

[238] Physorg.com, Moving Electrons at the molecular and nanometer scales: Possible applications for solar cells and other small-scale circuits, http://www.physorg.com/news3369.html (accessed January 2008).

[239] U.S. Environmental Protection Agency, 8.

[240] Ibid.

revolution to allow it to close the technology gap with the West, in particular, the United States. China also seeks to use globalization and its interdependence as a controlling factor over the United States.[241] Economic interdependence brought on through the process of globalization and its associated diffusion of technology makes customary export controls a losing proposition in trying to slow China's advance. These protectionist measures will not keep China from advancing new technological innovations. China has already obtained, diffused, and mastered much of the forbidden technologies that U.S. export controls seek to confine to the United States. Unfortunately, for China, these technological advances come with a price. However, the United States already provides China much needed technical collaboration in developing new innovative technologies. To ensure this collaboration is maximized within the United States, and among its allies, a collaborative-engagement policy that is comprised of a national STCL initiative, and dynamic technology controls is required.

China's serious research in nanotechnology, as a continuation of its successful 863 R&D program, shows its intention to close the technology gap with the United States. Without a serious commitment to research and development by the United States, this may indeed become reality. As shown in the case studies, educational complacency paired with ineffective export and foreign policies have jeopardized the U.S. lead in technology innovation. Military necessity early in the Cold War focused increased research into major innovation, so a new emphasis on frontier technologies such as nanotechnology, must ensure that the research output exceeds that of China.

The Nano Science and Technology Institute (NSTI) would be the main commercial coordination point for frontier technology related research. NSTI should encompass all future initiatives for competitiveness and meld them into this future technology. NSTI should create a program tailored to take on the research aspects of the collaborative-engagement STCL with its counterparts in the East Asia region, EU, and Canada. One main goal would be to collaborate with East Asian countries on such important issues as managing the risk future technologies, such as nanotechnology, have

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[241] Yong Deng and Thomas G. Moore, "China Views Globalization: Toward a New Great-Power Politics," *The Washington Quarterly*, 27:3 (2004): 126.

on the population, environment, and natural resources.[242] NSTI should expand and start a collaborative network throughout the East Asia region becoming a primary driver of this new policy. NSTI's extensive nanotechnology related research networks and databases make it an ideal collaboration leadership point for the United States. This will ensure U.S. nanotechnology collaborative dominance is maintained. This effort combined with DARPA, and the rest of the policies collaborators will preserve the United States' competitive edge into the future.

> Through the Nanotech Conference Series, the NSTI has made partnerships or received endorsements from a large range of significant nanotechnology industries or initiatives including; Defense Advanced Project Agency (DARPA), National Science Foundation (NSF), National Nanotechnology Coordination Office (NNCO), Sloan Foundation, Electron Device Society (IEEE-EDS), Nanotech-Inst of American Society of Mechanical Engineers (ASME), American Physical Society (APS), American Institute of Chemical Engineers (AIChE), American Ceramics Society, Swiss Nanotechnology Initiative, State of Massachusetts and over 250 participating, sponsoring or exhibiting technical and financial companies.[243]

The collaborative-engagement policy would focus U.S. innovative strengths toward regional collaborative efforts to solve the serious environmental and energy issues it now faces. This leadership will work to change the regional social dynamic, and reduce fear and mistrust while increasing strategic communications and trust. For the United States, this policy works to maintain U.S. technological competitiveness, which also translates to superior military technological access. This leadership position would also allow the United States to increase its regional soft power thus balancing China's rising regional influence. The collaborative-engagement with China will be critical with the impending revolution in technology brought on by the oncoming nanotechnology era. Nanotechnology has the greatest opportunity to solve these regional environmental and energy challenges. The United States working with China, and the region, can use its leadership to implement strong environmental controls and enforcement structures that

[242] Evan S. Michelson, "Nanotechnology Policy: An analysis of Transnational Governance Issues Facing the United States and China," *Woodrow Wilson International Center for Scholars* (2006): 3-7.

[243] NSTI website, http://www.nsti.org/about/relationships.html (accessed October 2007).

could help to open China's bureaucracy to positive change all the while controlling sensitive technology control to China more effectively and efficiently.

In the end, whoever masters innovation of such avant-garde technologies, such as nanotechnology, will control the global market and reap the rewards of this technological revolution. Such technologies will have military applications, and may require some form of export control as determined on a case-by-case basis. However, in a global economy, the increase in national security provided by such controls must far outweigh the loss of global commercial competitiveness and market shares to rival competitors, as seen in the satellite case study. This requires DARPA to collaborate in the R&D of new technology innovations to design in technology controls that work in the global economy. In response to this new global economy, the United States must re-form its educational system to become a more collaborative educational network, invest heavily in new technology, and strengthen the Wassenaar agreement to adapt to these new controls. It should also promote a domestic and international collaborative leadership structure to influence and control technological development in the global marketplace. These collaborative spheres of influence would have the shared innovative knowledge controlled by the strengthened Wassenaar agreement and technology controls.

If the United States fails to lead in collaborative technology development, it is plausible that China could surpass the United States in nanotechnology research, set new standards and control the market as the United States did throughout most of the Cold War. This could precipitate a new and very dangerous arms race resulting in new deadly military innovations from China following a more techno-nationalist path. This would lead to increasing regional fears, security dilemmas, and possible wars. In order to mitigate this undesirable outcome, a nationally led collaborative-engagement foreign and trade policy with China is required. This policy would center on U.S. Strategic Technological Collaborative Leadership (STCL) that uses U.S. innovative knowledge for the greatest utility, rather than relying solely on inferior protectionist or strict laissez-faire policy measures. This philosophy combines with a dynamic technology control structure built into the collaborative R&D, and collaborative spheres of influence, make this a winning proposition for the United States economic and security interests.

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